University of Alberta

An Analysis of Orthodontic Treatment Outcomes in Alberta Using the PAR Index and the American Board of Orthodontics Objective Grading System

By ©

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Chapter One

Introduction And Literature Review

1.1 General Introduction

Although esthetic improvement is a desirable goal of orthodontic treatment, the quality of outcome may be measured in other terms. For example, in a manner analogous to orthopedic medicine, the outcome might be measured as a degree of restitution from a handicap; in this case referring to the deviation of a malocclusion from the ideal i.e. the inadequacies in dental occlusion remaining after treatment. The alteration in occlusion from pre-treatment to post-treatment is difficult to quantify. While numerous efforts have been made to objectively assess the outcome and benefits of orthodontic treatment, the focus of this paper will be on two recently developed tools.

The objective of this thesis was to examine the basis for quantification of orthodontic treatment results, the quality of results themselves, and the inherent flaws present in the interpretation of those results. Tools to evaluate orthodontic treatment outcome are useful for epidemiological purposes as well as analysis of one's treatment results to gain insights into ways to improve patient care and treatment efficiency. The tools must be valid and reproducible for both the examiner/clinician and the patient being examined. Definitions and analysis of these terms is also contained in this paper.

This master's thesis investigates these two methods of evaluating the occlusion after orthodontic treatment. The first chapter is a general introduction into the uses of occlusal evaluation and methods for carrying out this task as well as consideration of the advantages and disadvantages inherent in their utilization. The first data chapter (Chapter Two) investigates the reproducibility of the PAR Index and

ABO Score. The ability of an index to be a reliable tool between examiners or for one examiner at different time intervals is an important criterion for its use. The second data chapter (Chapter Three) examines the Standard of Care in the orthodontically treated population of Alberta and attempts to make the concept of outcome standards more meaningful. The numerical values obtained from the PAR Index tool and the ABO OGS tool were used to illustrate a theoretical standard of care for the treatment outcome in the province from the dual perspectives of overall case improvement as well as remaining case inadequacies.

The following chapter (Chapter Four) is an investigation of some of the variables involved in orthodontic treatment and what effect they might have on treatment outcome. Patient factors such as age, gender, and extraction or non-extraction treatment plans were compared with outcome values such as final PAR Score reduction (case improvement) and ABO Score (case faults) as well as overall treatment time.

The final (Fifth) chapter serves as a discussion of the general findings of this thesis. It contains a last examination of the use of these tools as well as a general discussion on the positive and negative influences of their use when attempting to analyze the mass of orthodontic treatment effects. Implications for the use of these tools in research are discussed as well as recommendations for future research in the specific goal of assessing the positive benefits of orthodontic treatment. The appendix contains information used in scoring and interpretation of the results using the PAR and ABO indices.

This project has resulted partly because of the ongoing commitment of my supervisor, Dr. Paul Major, to ensure that orthodontic treatment continuously improves and that any changes in the delivery of orthodontic care are based on rigorously tested scientific evidence. To make a worthwhile treatment result in our patients we must first understand what our community of orthodontic peers view as valuable and meaningful measurements of quality. Thus, this study contributes to the knowledge of treatment effects and outcomes assessments both scientifically and philosophically.

1.1.1 Literature Review

A patient or his family may be referred to an orthodontist by their primary dental care provider, friends or relatives and they expect a certain level of education from that specialist.[1] The education represents a combination of knowledge, understanding, and skills tempered by experience gained from years in university and private practice.

A specialist in orthodontics and dentofacial orthopedics must meet specific educational standards established by the Commission on Dental Accreditation of the American Dental Association [2] and must possess advanced knowledge in biomedical, clinical, and basic sciences. [3] The Guidelines established for performing orthodontics and dentofacial orthopedics are "condition-based" and are related to the International Classification of Diseases, Clinical Modification, 9th Edition (ICD-9 Codes).[3]

There are various professionally accepted philosophies regarding diagnosis, treatment, and retention. The specialist (in consultation with the patient) is in the best possible position to evaluate the complex interactions regarding risk, benefit, and timing and choose the most appropriate treatment plan to accomplish the goals set out by both patient and practitioner.

In the American Association of Orthodontists' Clinical Practice Guidelines [3] it is stated that the document was not developed to establish standards of care but to be considered in the broad scope of professional practice. A practitioner may choose to deviate from its guidelines when necessitated by patient circumstances or other reasons. Successful outcome is not guaranteed despite strict adherence to the practice guidelines. Orthodontics differs from other areas of dentistry in ensuring quality of outcome [4] because: Correction of a malocclusion requires more time and appointments than the single-treatment procedures of most of dentistry; Orthodontics is aimed at treating a variation of normal morphology rather than a disease process; and the patient's chief complaint often reflects psychological or esthetic concerns.

1.1.2 Goals of Treatment:

In general the goals of orthodontic treatment are optimum dentofacial function, health, esthetics and stability. It is desirable to achieve all of these goals with the caveat that individual patients are biological entities with different problems, concerns and conditions that may prevent the attainment of optimal results in every case. The non-realization of these targets of treatment is not an indication of negligence or lack of competence by the orthodontist even when no obvious limiting factors are present.[5]

1.1.3 Limitations to Treatment Success:

Most people understand that, due to the biological constraints of the human being, orthodontic treatment may not be finished to a perfect result. [6] Excellent final results can be compromised due to individual patient variation from the prescription of the preadjusted appliance as well as the orthodontist's ability to place the appliance. [7] Extenuating circumstances probably occur more often than the orthodontist would like. The following are recognized boundaries [3] that the specialist has to observe when managing patient care and deciding on timing of treatment completion:

1. Severity of pretreatment condition
2. Pretreatment agreement to pursue limited objectives

3. Abnormal skeletal morphology or growth, both during and after treatment

4. Abnormal size, shape, or number of teeth

5. Aberrant tooth eruption patterns

6. Patient failures to initiate timely treatment, continue, or complete prescribed treatment

7. Compromised periodontal tissues

8. Persistent deleterious habits or abnormalities of muscle function relating to the dentofacial complex.

9. Inability or unwillingness of the patient to cooperate with treatment.

10. Failure to complete all recommended aspects of treatment

11. Poor quality, untimely or inappropriate integration of other recommended or required dental and/or medical services.

12. Medical complications or underlying systemic conditions

13. Patient transferring to another provider during orthodontic treatment

14. Patient transferring from another provider where the previous treatment plan limits the quality of outcome

15. Incomplete correction or relapse of orthognathic surgical procedures.

The process of orthodontic treatment considers these limits in a similar way for all patients. After the diagnostic process is completed, the orthodontist will consult with the patient (and parent) regarding the following items:

- the diagnosis and treatment plan
- a discussion of reasonable alternatives

- risks, compromises and limitations of the proposed treatment and its alternatives
- prognosis related to each alternative

The treatment plan is then executed to the best of the practitioner's abilities.

Fortunately in orthodontics serious complications are infrequent. However the patient must still be advised of the possibility of tooth markings or decay, shortening of roots, periodontal health compromise, or altered tooth vitality. [8-10] The fact that impressive treatment results can be partially negated by physiologic relapse is not an insignificant consideration in assessing treatment success. [11] One of the biggest risks is that of patients being dissatisfied with their dental or facial esthetics at the conclusion of treatment due to unrealistic expectations or perceptions.[12]Treatment outcome is dependent upon the treatment goals and objectives, the condition being treated, the stage of patient's dentofacial development and the treatment provided. Limiting factors as previously outlined must always be considered in evaluation of outcomes.

1.1.4 Risks and Benefits of Orthodontic Treatment

The American Association of Orthodontists published information for patients to help them in their treatment choices. [3] In general, the positive outcomes of orthodontic treatment include:

- Satisfaction of the patient's chief complaint
- Well-aligned teeth
- Good or improved occlusal function
- Good or improved dentofacial esthetics

- Good or improved environment for dentofacial development
- Desirable modifications of the size, shape, and position of the jaw(s)
- Stability of treatment results
- Good or improved dental and periodontal health.

The negative outcomes must be considered as well:

- Incomplete satisfaction of the patients chief complaint
- Poorly aligned teeth
- Poor or unimproved occlusal function
- Poor or unimproved dental and facial esthetics
- Premature root resorption of primary teeth
- Excessive root resorption of permanent teeth
- Significant decalcification or dental caries
- Unsatisfactory modification of the size, shape or position of the jaw(s)
- Instability of treatment results.

Following orthodontic treatment, a retention plan must be included which addresses the patient's original malocclusion, treatment objectives, the results achieved and any limiting factors. Merely completing orthodontic treatment does not guarantee stability of an excellent outcome due to posttreatment changes resulting from growth, maturation, aging, lack of retention protocol compliance, periodontal issues, resumption of oral habits, or trauma. Occlusal deterioration after orthodontic treatment is almost universal so it is imperative to do our best in the treatment of any given malocclusion. [11] [13]

1.1.5 Assessment of Treatment Outcome

It has been reported that the difficulty in achieving an ideal occlusion increases as the severity of the original malocclusion increases.[14] The final result of treatment may be influenced by many other factors such as age of the patient, gender, cooperation, distance the patient lives from the operator, amount of chair time utilized, and whether fixed or removable appliances were used for treatment.[15] [16] It is difficult to say how much each factor contributes to the final outcome.

The quality of outcome or degree of success, according to Bergstrom et al[17] can be viewed in terms of:

- reduction of treatment need
- stability of outcome
- patient satisfaction/fulfillment of initial desires/expectations
- parent satisfaction with esthetics, fees, duration
- Amount of residual deviation from ideal tooth relationships (i.e. the occlusal result).

Ideally, a thorough objective evaluation of the quality of orthodontic treatment should also involve improvement in skeletal relationships, facial profile, psychosocial factors such as perception of self-worth, and lack of iatrogenic complications.

To assess treatment success, Andrews [18] gathered 120 non-orthodontic "normal" models for analysis to see what the "best of nature" had in terms of identifiable characteristics. He chose models of teeth which had never had orthodontic treatment, were straight and pleasing in appearance, had a bite which generally looked correct, and in his judgment would not have benefited from orthodontic treatment. He then compared these untreated models to a large sample of 1150 treated cases from displays of "excellence" at national orthodontic meetings. Six differential qualities of the occlusion were noted in the occlusions of all examined cases. Andrews validated them by finding that these six characteristics were not only present in the 120 case non-orthodontic sample but also that the lack of even one of the six was a defect predictive of an incomplete end result in treated cases. The six "keys" to an ideal occlusion shared by all of the models were:

1. molar relationship
2. crown angulation, or mesiodistal tip
3. crown inclination, or labiolingual inclination, or torque
4. no rotations
5. no spaces, interproximal contact points were tight
6. occlusal plane varied from flat to a slight curve of Spee.

If we adhere to Andrew's Six Keys to Normal Occlusion [18] we can achieve many of the patient's treatment goals as well as our own. Andrews suggests that if we know what constitutes "right", we can then directly, consistently, and methodically identify what is "wrong" with cases in treatment or needing treatment. Patients desire optimum form (esthetics) which should be present if we correct crown angulations, crown inclination, rotations, and spacing. The end result however may still be lacking in terms of molar relationship and a flat occlusal plane despite reasonable esthetics being achieved. Andrews admits that defining occlusal adequacy by Angles' classification [19] alone is insufficient. The ideal occlusion is arguably the ultimate goal to be achieved in orthodontic treatment. However there is little evidence for the validity of this goal. [20] A valid question at this point is "how can the validity of this goal be assessed"?

Coupled with the uncertainties of dealing with the human body, the decision on when to terminate treatment is further complicated by a subjective evaluation that can vary from one clinician to another. While an orthodontist may feel treatment is complete, parents will be unsatisfied with terminating treatment while any amount of excessive (by the parent's opinion) overjet exists. [21] Comparison to Andrews' keys alone is still a subjective appraisal process.

Gottlieb [22] advocated the routine evaluation of treatment results. He stated that this practice will inevitably lead to a mentality of self-teaching and treatment result improvement. He qualifies this with the assertion that model analysis, while prudent, is not going to elucidate the whole picture of treatment success and outcome. It is merely a standard way of allowing for the grading of characteristics that can be easily measured from the models. The key finding of analyzing one's own outcome not once but repeatedly with a large enough sample is that a pattern should emerge if there is any measurable factor that continuously requires improvement. This should result in the changes required to bring about a positive increase in a practitioner's Standard of Care.

The term *standard of care* is defined in several ways. It is "a statement of activities consistent with minimum safe professional conduct under specific conditions as determined by professional peer organizations". [23] It is also defined by Mosby [24] as "a written statement prescribing the rules, actions, or conditions that direct patient care. Standards of care guide patient practice and may be used to evaluate performance ". The best standard of care is the one that does the most good and the least harm, obtaining the best, most beneficial result for that patient.

The AAO lists treatment goals as "optimum dentofacial function, health, stability, and esthetics" [3]; however it does not establish standards of care.

The profession has been searching for an objective and valid way to measure treatment outcome in order to establish guidelines. Although opinions regarding need for and outcome of orthodontic treatment could show wide variation, the profession has made an effort to reduce subjective bias and standardize evaluation criteria by the use of occlusal indices. [25] An occlusal index in this case refers to a rating or categorizing system that assigns a numeric score or alphanumeric label to a person's occlusion.

At present the development of indices has been primarily for two reasons: to assess need, and to assess outcome of treatment. [26] Valid and reliable assessments serve a number of other functions: [27]

- They can inform the public of relative merits of orthodontic services and their timing to resolve particular malocclusions.
- To assist 3rd party insurers in allocation of resources to essential verses elective services.
- To guide patients when selecting potential provider of orthodontic treatment. E.g. Specialists verses **non**-specialists.
- To assist in arbitrating cases when outcomes fall below expected objectives.

It is a basic requirement of any index, diagnostic test, or system of measurement that it should be valid and reproducible.[20] Shaw et al[20] list these and other properties for an ideal index which include:

1) Reliability
2) Validity
3) Sensitivity to the needs of the patient
4) Acceptability to both the public and the profession
5) Be administratively simple to operate
6) Be easy to learn by both trained dental and non-dental personnel
7) Sensitivity throughout the scale
8) Be amenable to statistical analysis
9) Require a minimum of judgment
10) Be able to promptly detect a shift in group conditions.

One of the main requirements of any measuring instrument in order for it to be valid is that it be a true "living" tool.[3] The nature of orthodontic treatment is a dynamic process that will by necessity change with the evolution of the science and art of orthodontics and dentofacial orthopedics. Thus the tool used to assess the outcome must revolve around a constantly updated set of "truths".

Validity of an index requires that it accurately measure what it purports to measure. Validation for indices of treatment outcome is difficult since longitudinal data on the implication of malocclusion for orofacial health and psychosocial wellbeing is scant[16]. In this case, the next best means of validation (i.e. the gold standard) is to obtain the consensus opinion of specialists. The validity of the PAR

Index has been demonstrated in several studies.[28 29] Reliability of an occlusal index requires that repeated measures by the same or different examiners yield the same result. There are two main sources of bias when examining the quality of treatment outcome: the examiner, and the measuring instrument.[30] Certain components are easier to measure than others. Keeling et al[31] found poor reliability in measuring facial esthetic characteristics but better reliability in measurement of overbite, overjet, molar classification and crossbite. This lends credibility to the quantitative evaluation of occlusal features to indicate case severity. Since it is difficult to measure all possible factors related to outcome the use of indices of malocclusion is warranted to produce a limited but systematic and objective evaluation.

A further and more detailed discussion of two currently utilized outcome measures follows; The PAR Index[32] and the American Board of Orthodontics Objective Grading System.[33]

1.1.6 The PAR Index (Peer Assessment Rating)

The PAR Index was developed in response to directives to investigate ways to monitor orthodontic standards in the General Dental Service of Great Britain. [34] It is an epidemiologic tool and was validated against a cross-section of dental opinion over a wide selection of cases. [34] In essence it (the final "PAR Score") was found to have close agreement with expert ratings of deviation from normal occlusion [34]. If used as intended to assess samples from caseloads rather than individual cases it is a reliable tool to assess performance of practitioners or services. [41] It is now used extensively in Britain and Europe. Its use has been documented in the United States in several studies [29 35] which validated the PAR with U.S. orthodontists' opinions of quality of treatment outcome.

The PAR Index has been used frequently in the literature for outcome assessment relative to treatment factors such as timing, extraction philosophy, experience of the orthodontist, and type of appliance used. [26 36-43].

To illustrate its portability, the PAR index was used to objectively evaluate treatment outcome in 220 patients in a location other than the United Kingdom (Norway) where it was developed [44]. The authors found that the PAR could be used to analyze samples (i.e. multiple cases) from individuals as well as the health care systems available in Europe. The effect of different levels of experience of care providers on outcome has been investigated. [37] A retrospective investigation used the PAR index as an objective method of evaluating the difference in treatment outcome due to technological and material improvements in orthodontics after a 10 year period. [26] Perhaps not surprisingly, they did find that advances in orthodontics were detectable via the positive effect on PAR index scores for the group treated in the more recent time period. Other uses for the PAR Index include evaluation of outcomes due to patient variables such as dental (Angle) classification [37] where it was found that this factor has no apparent influence on quality of the result.

The PAR Index was formulated over a series of six meetings with a group of 10 experienced orthodontists in 1987 (British Orthodontic Standards Working Party). Richmond [34] states that the use of precise criteria is essential, requiring a quantitative objective method of measuring both malocclusion and efficacy of treating that same malocclusion. Over two hundred dental casts were examined and discussed until agreement was reached regarding which individual features could be assessed to obtain a valid estimate of the occlusion and alignment at any stage of treatment or prior to treatment.

The PAR Index is typically applied to an individual's pre- and post-treatment study casts. Scores are assigned to the various occlusal traits that make up a malocclusion. The individual scores are summed to obtain a total that represents the degree a case deviates from normal alignment and occlusion. A score of zero indicates good alignment and higher scores (rarely beyond 50) indicate increased levels of irregularity of the dentition. The difference between pre- and post-treatment PAR scores thus reflects the degree of improvement due to orthodontic intervention. [32 34] See Appendix for PAR Index scoring conventions and scoring tables.

The PAR Index is composed of 7 main components: (explanation follows)

- Upper and lower anterior segments (2 scores)

- Left and right buccal occlusion (2 scores)
- Overjet
- Overbite
- Midline or centreline

The features recorded for the upper and lower anterior segments (scored separately) are crowding, spacing, and impactions in the zone from mesial of the cuspid to mesial of the cuspid. Crowding is often found in the form of contact point displacement thus this value is recorded as the shortest distance between the contact points of adjacent teeth. Greater displacement results in greater score and is perceived to equate with an increase in the severity of malocclusion.

The buccal occlusion is recorded for both left and right sides and the fit of the teeth is noted in all three planes of space, from canine to the last molar. Scores are assigned in an ordinal fashion for the antero-posterior, vertical, and transverse sections for each buccal segment. Discrepancies are recorded when the teeth are in occlusion (hand-articulation of the dental casts). It is important to note that the PAR Index does not discriminate against either mesio- or disto-occlusions but only assesses the cuspal interdigitation of the buccal segments. There is little allowance allowed for deviation from full intercuspation.

Overjet; both positive and negative are recorded for all incisor teeth using the most prominent incisor overjet and recording to the most labial aspect of the incisal edge. In cases where a large overjet is found in conjunction with anterior crossbite the scores for both features are summed and recorded.

Overbite records the worst vertical overlap or open bite of any of the four incisors. This is done relative to the coverage of the lower incisors or degree of open bite severity.

Lastly the midline or centerline discrepancy is recorded as the relation of the upper to the lower dental midline in terms of lower incisor width. Again, an ordinal score is used depending on whether the midline is displaced by one third, one half, or more of the lower incisor width.

A specific PAR ruler has been fabricated to ease measurement and increase reliability (Figure 1.1). The ruler summarizes the index as well as allows faster assessment of the dental casts as it is formed from a clear plastic that can be placed over or along teeth and the score for that particular component is simply noted by viewing through the ruler. The use of the ruler with the brief summary printed upon it reduces the need to cross-reference scoring keys of a complicated nature. [34]

1.1.7 Validation of the PAR Index

Validation refers to whether the PAR Index measures what it purports to measure. In general terms the validation process involves comparison of a subjective measure against an objective measure of the characteristic. In this case the collective subjective agreement of a group of orthodontists on the severity of occlusal components of a malocclusion is considered to be the Gold Standard.

The PAR Index has been validated in accordance with current British Orthodontic opinion. [34] A panel of 74 dentists was invited to participate, the majority being orthodontic consultants and specialists but also including 15 general dental practitioners and 11 community dentists. Utilizing a representative sample of 272 dental casts, they expressed views relating to the relative importance of each of the 5 main components of the PAR index. Linear correlations between subjective scores and the PAR Index components were calculated and after multiple regression technique, each component was then "weighted" statistically to improve its validity. [34] Features such as overjet were found to be worse than a component such as molar interproximal contact displacement. Some of the original PAR Index components did not appear to have any predictive power and thus were excluded from the weighted PAR index. To summarize, upper and lower anterior crowding is multiplied by 1, left and right buccal occlusion by 1, overjet by 6, overbite by 2 and centreline by 4. This gives the final "UK-weighted", or United Kingdom weighted PAR score derived from the raw PAR score. The PAR Index was similarly validated using a smaller sample of specialists in the United States to give it a "US-weighting". [29]

1.1.8 Calculation of Case Improvement

The amount of improvement from pre-treatment to post-treatment that is visible in a dental cast is objectively assessed using the PAR index. However this improvement can be viewed in absolute terms, weighted score reduction, and percent reduction. The usual convention is to express improvement in terms of percentage change as this reflects the change relative to the pre-treatment score. The actual reduction in weighted PAR scores is still relevant however. A change in score from 50 to 10 representing an 80% improvement may be numerically similar to a change in score from 15 to 3; however the overall 40 point reduction in the first example would represent a much larger degree of improvement from the original malocclusion. Also a case that has a PAR score of 15 may not be considered to even need treatment whereas a score of 50 is evidence of a severe malocclusion that should be addressed. The difference between the pre-and post-treatment scores thus reflects the success of treatment. [32 34 45] As the post-treatment score tends towards 0, the deviation from normal is less. It is not possible to achieve a perfect 0 score in all cases but by convention a measure of 10 or less indicates an acceptable level of alignment and occlusion, while 5 or less represents an almost ideal occlusion. A reduction of more than 70 % is considered to demonstrate a high standard of treatment. [32 46] Richmond states that a case must improve by at least 22 points before it can be classified as "Greatly Improved". Obviously a case that did not deviate from normal by a large degree will not show great improvement if the pretreatment score is not severe enough. For a practitioner to show consistent treatment to a high standard the majority of his cases should show at least a 70% reduction in PAR and the amount of cases showing "Great improvement" should exceed 40 percent while the number of cases that are "worse or no different" after treatment should be negligible. [32]

1.1.9 Advantages and Uses of the PAR Index

The application of any objective index of malocclusion offers several advantages: [32 35 43 47]

- Uniformity: an objective index should reduce varying opinions of orthodontists as guidelines are in place that can be observed and followed when assessing a patient's need for treatment.

- Safeguards for patients: Patients with borderline treatment needs may find that the objectivity of the index leads them to accept their situation rather than be exposed to potential risks of iatrogenic complications due to orthodontic treatment.

- Patient counseling: Patients may be more fully informed of the degree to which their malocclusion deviates from ideal and thus be enabled with an opportunity for a better decision making process when it comes to deciding on avenues of treatment.
- Flexibility: The weighting of the PAR Index could be changed to reflect differing standards in the future or in different geographic areas where local opinions differ.
- Resource allocation and planning: In geographical areas that utilize public resources for health care including dental and orthodontic treatment it is unavoidable that there must be a limit on expenditure. Manpower and resource planning are becoming more critical and are assisted by the development of cutoff points where the amount of treatment delivered can more adequately meet the treatment need.
- Monitoring and promotion of standards: as an indicator of clinical performance for third party payment, the PAR Index shows utility. However it is equally effective for evaluating different systems of orthodontic treatment in terms of efficacy and can be used for introspection by individual practitioners to periodically assess their own treatment delivery.

In summary, the PAR index is considered a useful tool because of its simplicity, ease of use, portability, and amenability to different weighting systems based on changing orthodontic opinion. [48] It lends itself to statistical analysis and offers uniformity and objectivity in the standardized evaluation of treatment outcome. [49] Its reliability was proven in the initial publication using the Intraclass Correlation

Coefficient. It is generally agreed that values of R greater than .75 indicate excellent agreement [50] and the PAR Index was found to have an R value of .93.

1.1.10 The American Board of Orthodontics Objective Grading System (ABO OGS)

The second treatment outcome assessment tool to be considered in this paper is the ABO OGS, a system developed in conjunction with the examination process required as part of becoming a diplomat of the American Board of Orthodontics. It is worthwhile to look briefly at the ABO prior to discussing the outcome evaluation process that it has created.

1.1.11 History of the American Board of Orthodontics (ABO)

The American Board of Orthodontics was established on July 16, 1929 by the American Society of Orthodontia in Estes Park, Colorado. The name of the Society was changed to the American Association of Orthodontists in 1938. Albert H. Ketcham founded the ABO after an address on accreditation to the American Society of Orthodontia. The ideals of the board were to instill professional excellence in the minds of its members. [51] It is important to bear in mind that clinical and diagnostic expertise was in the mind of the individual practitioner at the time. Formal training, not to mention postdoctoral education, was virtually absent. There was an initial resistance to the formation of this board, as several pioneers feared that it might become an elitist organization. However, Dr. Ketcham stated that the Board's aim was to establish a standard of fitness to practice orthodontics and raise the standards of the practice to the equivalent of then existent medical specialties. It is clear that at the time when there was little formal training in orthodontics there should be a distinction between the general dentists who "dabbled in the arts" of orthodontics and those who took the practice of orthodontia and turned it into dentistry's first recognized specialty. It is also clear that the founding fathers of the ABO did not intend for it to fragment the specialty itself into those who are or are not Board Certified. Members who fulfilled the requirements of the Board in the early years did so "on their records". In 1940 it was resolved to bring about controls for definite requirements. A minor controversy occurred in 1949-50 when the American Dental Association refused to recognize the ABO, but this decision was reversed in late 1950 when the ADA recognized the ABO as the official certifying body in orthodontics. In the years that followed, recognition of Boarded specialists working for the federal government accorded these men a 25 % increase in base salary. From 1950-1978 several changes in requirements for certification occurred, and at this time it is still a requirement that an applicant: be a member of the American Association of Orthodontists, write and pass the Phase II written examination, and present a number of pre-defined cases for evaluation by ABO examiners (Phase III). At present the Board considers its certification to be the highest professional accomplishment in that peers confer the status of diplomat of the ABO utilizing exacting standards. "The objective grading system for assessing the final occlusal results of orthodontic treatment helps to satisfy our mission of establishing and maintaining the highest standards of clinical excellence and to contribute to the development of quality education programs in orthodontics".[52]

In its mission statement the Board defines four main objectives: [53]

1) to evaluate the knowledge and clinical competency of graduates of accredited orthodontic programs;

2) to reevaluate clinical competency throughout a diplomat's career through recertification;

3) to contribute to the development of quality graduate, postgraduate, and continuing education programs in orthodontics; and

4) To contribute to certification expertise throughout the world.

The first objective raises some questions as the graduates should already have been thoroughly evaluated in order to finish their course. If these men and women indeed graduated (indicating an acceptable degree of accomplishment of their program's requirements) as well as came from a program with ADA accreditation, there should not necessarily be a need to evaluate them. The public already expects that they will receive nothing less than optimal treatment from the graduates of specialty schools which have the backing of the university institution as well as the American Dental Association approval. In fact, the entire concept of competency is negated unless certain standards are built in to the multiple levels of education required in order for a specialist to enter the independent field of practice. [2] Competency describes the knowledge, skills, attitudes, and values that a graduate must have. While it may be the "minimum" requirements, it is built in that it is an acceptable level of requisite understanding and practicing of the above concepts or by definition the program from which the graduate came would not have received accreditation.

The ABO markets itself as a worthy but difficult group to join. Key Reasons for putting oneself forward for Board Examination are: [53]

- Personal growth as a practicing clinician

- Increased self confidence
- An invaluable learning experience
- Improved standards of practice

1.1.12 The ABO certification process

There is currently a specific three-phase process to complete in order to become ABO-certified.[33] At completion of formal specialty training at an ADA-accredited Orthodontic Specialty Program, an applicant completes Phase I assuming that s/he applies in accordance with the rules of the ABO and is accepted after evaluation of credentials. Phase II is a comprehensive written examination that assesses the candidate's knowledge of basic sciences and clinical concepts. After writing and passing this ABO-produced examination, the applicant has then completed Phase II, and is said to be "Board Eligible". The third step is a clinical examination composed of two parts: Oral Examination, and Candidate Case Report Examination (CCRE). At this point, the applicant has several years to work in practice while gathering records of treatment for specific types of malocclusion for presentation to the ABO. The applicant has up to 10 years to initially take the Phase III clinical examination. The candidate is now required to display 10 case reports from specific categories of malocclusions. In addition, the candidate is only required to exhibit records made before and soon after orthodontic treatment. The candidate must have made the diagnosis, formulated a treatment plan, constructed the appliance, monitored progress and carried out regular appliance adjustment, and completed treatment. When the applicant has sufficient cases to present, they (the cases) are considered by "Calibrated ABO Examiners" and if judged to be treated to ABO standards the applicant is awarded Diplomate status. The dental casts and panoramic radiographs only comprise one aspect of the Phase III grading process. Adequacy of records, treatment plan and execution are all considered in the final score for an applicant. According to the ABO information website, (http://www.americanboardortho.com/professionals/road_to_cert/common/info/#):

Evaluation of the orthodontic treatment results presented in the CCRE exhibit will be based on the attainment of the following orthodontic treatment objectives:

1. Treatment complementing facial growth,
2. Facial harmony -- balance and harmony of the soft tissue and proper proportion of facial structures,
3. Maximum esthetics of the teeth and face,
4. Dental health -- maximum health of the teeth, the supporting tissues and the adjacent structures,
5. Optimal function, free of interferences and trauma,
6. Excellent occlusion,
7. Favorable intercuspation of the teeth,
8. Alignment of permanent second molars,
9. Favorable overjet and overbite relationship,
10. Favorable correction of rotations of all teeth,
11. Favorable axial inclination of all teeth,
12. Complete space closure,
13. Coordinated ideal arch form with all the teeth aligned within their supporting structures,

14. Good vertical control,

15. Good stability.

It is interesting to note that the PAR Index directly measures only objectives number 6, 8,9,10, and 12. Changes in facial profile, psychosocial attitudes, and cephalometric measures that reflect skeletal aspects are not considered in the PAR Index. [35] However, the ABO Objective Grading System does not directly consider these objectives either. The ABO expects all case exhibits to be well treated. Simply put, poorly finished case exhibits, even though they may be difficult, are not acceptable. Conversely, very easy or unchallenging cases, even though they may be finished perfectly, are not acceptable. Because the Board examiners can only evaluate the records as presented, all treatment, especially occlusal interdigitation should be completely finished. Examiners will not presume that favorable changes will occur with growth or time for patients that are not completely finished. Second molars should be fully seated and in occlusion.

1.1.13 The Objective Grading System

In 1998 the ABO published the Objective Grading System (OGS) for dental casts and panoramic radiographs. [33] A summary of the ABO conventions and ruler use is found in the Appendix. One of the ABO's main reasons for developing its own system of evaluating the outcome of orthodontic treatment was because it felt that other available indices do not provide enough precision to discriminate between subtle tooth position details found in a typical ABO case report. As a beginning point in 1995 the ABO Phase III examiners studied submitted case reports. Out of 100 cases, 15 tooth position criteria were evaluated and measured. It was discovered that 85% of the inadequacies of final results occurred in 7 out of 15 of these criteria (*Alignment, marginal ridges, buccolingual inclination, overjet, occlusal relationships, occlusal contacts, and root angulations*). The following year a larger sample size of 300 cases was evaluated (unpublished data) with the majority of "inadequacies" occurring in the same seven occlusal criteria but adequate reliability was found to be a problem between examiners. The ABO recommended development of a measuring instrument to make this examination process more reliable. The following year, another study (unpublished) using 832 dental casts and panoramic radiographs was performed using the newly constructed measuring instrument (figure 1.2). and the category of "*interproximal contacts*" was added to the scoring criteria (no reason given for adding this category). Finally in 1998 a fourth test of the scoring criteria was performed after a training and calibration session to refine the measuring system and establish a validity or cutoff for passing the dental cast and panoramic radiograph grading section of the exam. The ABO examiners felt that this last test was extremely successful in establishing the OGS as an objective system as well as setting standards for passing this component of the Phase III exam. The ABO currently uses this same set of 8 criteria to score dental models and panoramic radiographs, and by providing potential ABO diplomat applicants with all information relating to this system, encourages applicants to *pre-select* cases that will pass the ABO OGS.

Based on its 1997 and 1998 field tests utilizing both subjective and objective methods of scoring the ABO directors established a passing score for the Dental Cast and Panoramic Radiograph evaluation section of the Phase III examination. Essentially, a case that loses more than 30 points will fail while a case that loses less than 20 points will generally pass that portion of the exam. Of course the ABO also considers other information available for each patient (quality of records, appropriateness of the treatment plan, objectives for positioning of the maxilla, mandible, their respective dentitions, and facial profile). From its own studies, the ABO reports that it is confident that the cutoff score to pass this component of the examination is valid (unpublished data). They also state that reliability is insured by using the precise measuring instrument in addition to training and calibration of the examiners prior to each examination. They have established a confidence interval to account for inter-rater variability as well (unpublished data).

1.1.14 Rationale for the individual ABO OGS criteria:

The ABO Objective Grading System for scoring dental casts and panoramic radiographs contains eight criteria. These are: alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, interproximal contacts, and root angulations. [33] The rationale for using these criteria is stated in the following section.

Alignment is usually a fundamental objective of any orthodontic treatment plan. Therefore, it seems reasonable that any assessment of quality of orthodontic result must contain an assessment of tooth alignment. In the anterior region, the incisal edges and lingual surfaces of the maxillary anterior teeth and the incisal edges and labial-incisal surfaces of the mandibular anterior teeth were chosen as the guide to assess anterior alignment. These are not only the functioning areas of these teeth, but they also influence esthetics if they are not arranged in proper relationship. In the

6

maxillary posterior region, the mesiodistal central groove of the premolars and molars is used to assess adequacy of alignment. In the mandibular arch, the buccal cusps of the premolars and molars are used to assess proper alignment. These areas were chosen since they represent easily identifiable points on the teeth, and represent the functioning areas of the posterior teeth. The results of the four field tests showed that the most commonly mal-aligned teeth were the maxillary and mandibular lateral incisors and second molars, which accounted for nearly 80% of the mistakes.

Marginal ridges are used to assess proper vertical positioning of the posterior teeth. In patients with no restorations, minimal attrition, and no periodontal bone loss, the marginal ridges of adjacent teeth should be at the same level. If the marginal ridges are at the same relative height, the cementoenamel junctions will be at the same level. In a periodontally healthy individual, this will result in flat bone level between adjacent teeth. In addition, if marginal ridges are at the same height, it will be easier to establish proper occlusal contacts, since some marginal ridges provide contact areas for opposing cusps. Based upon the four field tests, the most common mistakes in marginal ridge alignment occurred between the maxillary first and second molars. The second most common problem area was between the mandibular first and second molars.

Buccolingual inclination is used to assess the buccolingual angulation of the posterior teeth. In order to establish proper occlusion in maximum intercuspation and avoid balancing interferences, there should not be a significant difference between the heights of the buccal and lingual cusps of the maxillary and mandibular molars and premolars. The Directors use a special step gauge to assess this relationship (see figure 1.1). Some latitude is allowed, however in past field tests significant problems were observed in the buccolingual inclination of the maxillary and mandibular second molars.

Occlusal relationship is used to assess the relative anteroposterior position of the maxillary and mandibular posterior teeth. In order to achieve accuracy and reliability in measuring this relationship, results of previous field tests have shown that the most verifiable method of scoring this criterion is to use Angle's relationship. Therefore, the buccal cusps of the maxillary molars, premolars, and canines must align within 1 mm of the interproximal embrasures of the mandibular posterior teeth. The mesiobuccal cusp of the maxillary first molar must align within 1 mm of the buccal groove of the mandibular first molar.

Occlusal contacts are measured to assess the adequacy of the posterior occlusion. Again, a major objective of orthodontic treatment is to establish maximum intercuspation of opposing teeth. Therefore, the functioning cusps are used to assess the adequacy of this criterion; i.e., the buccal cusps of the mandibular molars and premolars, and the lingual cusps of the maxillary molars and premolars. If cusp form is small or diminutive, that cusp is not scored. In past field tests, the most common problem area has been inadequate contact between maxillary and mandibular second molars.

Overjet is used to assess the relative transverse relationship of the posterior teeth, and the anteroposterior relationship of the anterior teeth. In the posterior region, the mandibular buccal cusps and maxillary lingual cusps are used to determine proper position within the fossae of the opposing arch. In the anterior region, the mandibular incisal edges should be in contact with the lingual surfaces of the maxillary anterior teeth. In past field tests, the common mistakes in overjet have occurred between the maxillary and mandibular incisors and second molars.

Interproximal contacts are used to determine if all spaces within the dental arch have been closed. Persistent spaces between teeth after orthodontic therapy are not only unesthetic, but can lead to food impaction. In past field tests, spacing is generally not a major problem with ABO cases.

Root angulation is used to assess how well the roots of the teeth have been positioned relative to one another. Although the panoramic radiograph is not the perfect record for evaluating root angulation, it is probably the best means possible for making this assessment. If roots are properly angulated, then sufficient bone will be present between adjacent roots, which could be important if the patient were susceptible to periodontal bone loss at some point in time. If roots are dilacerated, then they are not graded. In past field tests, the common mistakes in root angulation occurred in the maxillary lateral incisors, canines, second premolars, and mandibular first premolars.

1.1.15 The Marketing of ABO certification:

Since its development the ABO has listed as its key benefits: 1) personal growth and satisfaction; 2) it instills confidence; 3) increases levels of professional competency though self-analysis; 4) it is a valuable learning experience; and 5) it improves the standards of orthodontics in North America and throughout the world. The ABO states that the board-certified orthodontist must recognize that board certification does not make them better than the non-certified orthodontist next door. In fact, the Board's certificate has no legal standing at all.[53] It is a certification of attainment. Unfortunately it "does not confer any legal qualification, privilege, or license to practice orthodontics".[53] Certification is not to be used to promote an orthodontist as being better than his colleagues. However, a contradiction exists. It is certainly true that ABO Diplomats are considered "better" than their non-certified counterparts in the specialty.[54 55]

1.1.16 Disadvantages and limitations of Occlusal Indices

While the use of occlusal indices is considered to be valid and accurate they have several limitations. The PAR index as well as the ABO OGS is the total of many subcomponents which can lead to errors due to the omission of any of their elements.[50] A major failing of all occlusal indices, by definition, is Esthetics. Occlusal indices are not sensitive to psychosocial needs and interactions of the patient.[56] There is little universal agreement on the idea of perfect dental esthetics or occlusion.[57] The PAR index is also not detailed enough to record minor irregularities that patients in fact may be deeply concerned about.[58] Self esteem and self confidence play a large role in healthy social development today and it must not be underestimated to what degree the teeth affect these attributes of one's personality.[59] The PAR is limited to dento-alveolar change. It has been suggested that benefits from treatment may be better measured in terms of reduction of health risk or improvement in degree of esthetic impairment.[41]

Since the PAR score was developed as a tool to measure appropriate utilization of limited funds such as what is available in Great Britain or Sweden, it is not surprising to see limited or delayed introduction of the PAR index in North America where fee-for-service is the underlying economic stimulus in orthodontics. [60] In addition the decision to treat and when to finish treatment is complex but is often more weighted to parent or patient demand and less on defined occlusal criteria. [35]

The developers of the PAR Index state that its adoption should provide standardized methods of measurement for epidemiological, clinical, or audit studies. However, even with well defined guidelines, examiners can be unreliable. Careful training and calibration provides no guarantee that results will be comparable due to differences in experience, personal biases regarding severity or individual aptitude. [50]

The PAR Index and ABO OGS cannot be used to measure function. Holding a set of plaster casts together in the hands gives no indication of excursive movements or “occlusion” since the teeth as well as the neuromuscular and temporomandibular architecture define the occlusion for that particular patient.

The PAR cannot identify improper incisor inclination. [43] It also does not score the deciduous dentition easily as deciduous teeth are excluded in the PAR Index scoring system. [32]

Some authors [61] feel that the PAR has reasonable validity but the index is limited by its overly high emphasis (weighting) on overjet. It is also felt that the use of one index on all types of malocclusion is inappropriate due to the occlusal features varying in importance in different classes [61].

A possible problem with using pre-treatment PAR as being analogous to treatment need is its weighting. Research has shown there is not a clear-cut risk of periodontal disease due to excessive overjet. [60] The PAR index places low weighting on the buccal occlusion and very high weighting on the overjet as determined by the panel agreement. [32] It is possible that orthodontic opinions may have changed since 1992. Weightings must be appropriate to the population being studied (both patients and orthodontists) as well as to the nature of the individual malocclusion.

Treatment efficiency is not considered. A case that takes 12 months to treat versus a case requiring 36 months is judged similarly. Although there is no conclusive evidence that early treatment is better treatment, there is an "early treatment" category in the ABO case requirements. [62] The PAR Index and ABO OGS do not evaluate periodontal health, root resorption, patient satisfaction and patient compliance. The occlusal index only looks at the static dental models and does not account for dynamic improvements or relapses of the occlusion.

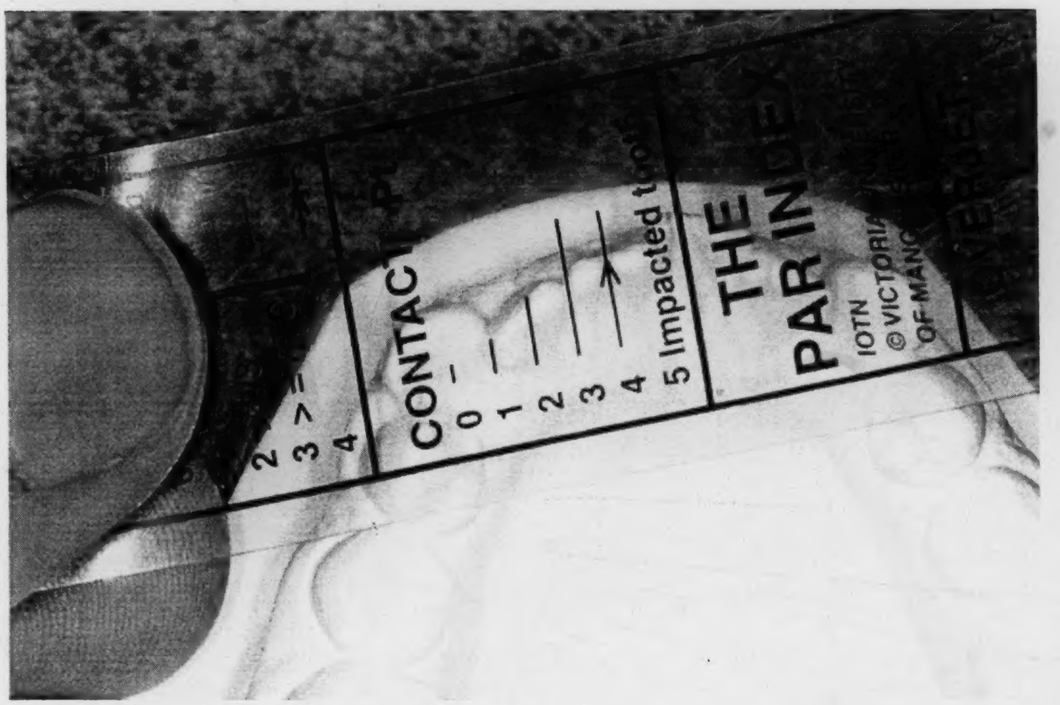
The PAR index and ABO OGS are limited in that the quantitative scores do not reflect changes in facial profile, skeletal foundation, and cephalometric parameters. These variables are difficult to measure for several reasons. [29 40] Individual biologic variations in facial growth and direction make it difficult to sort out changes due to normal growth and development from those due to orthodontic treatment. There is little universal agreement on what constitutes ideal cephalometric goals. Similarly there are no ways to measure facial profile or esthetics as an outcome variable that would be agreed upon as well as show reliability and validity.

The PAR is only a “proximate measure” of treatment outcome (i.e. it only measures the extent to which the orthodontist succeeded in the primary or immediate goal of most treatments – to improve the patient’s dental alignment and occlusion). It is not designed to measure the “ultimate outcomes”, that is, improved appearance and psychosocial wellbeing or reduction in susceptibility to oral disease or dysfunction. [25] Also, no index is perfectly sensitive to the needs of the individual patient i.e. the impact of treatment on esthetics and self-confidence. [25] The American Association of Orthodontists recognizes the limits of occlusal indices and does not endorse any index. [27]

Thus the only way to measure *many* of the effects of orthodontic treatment is with an occlusal index.

Figures:

Figure 1.1 PAR Index ruler in use showing contact point displacement measurements between lower anterior teeth.


CONTACT
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THE PAR INDEX
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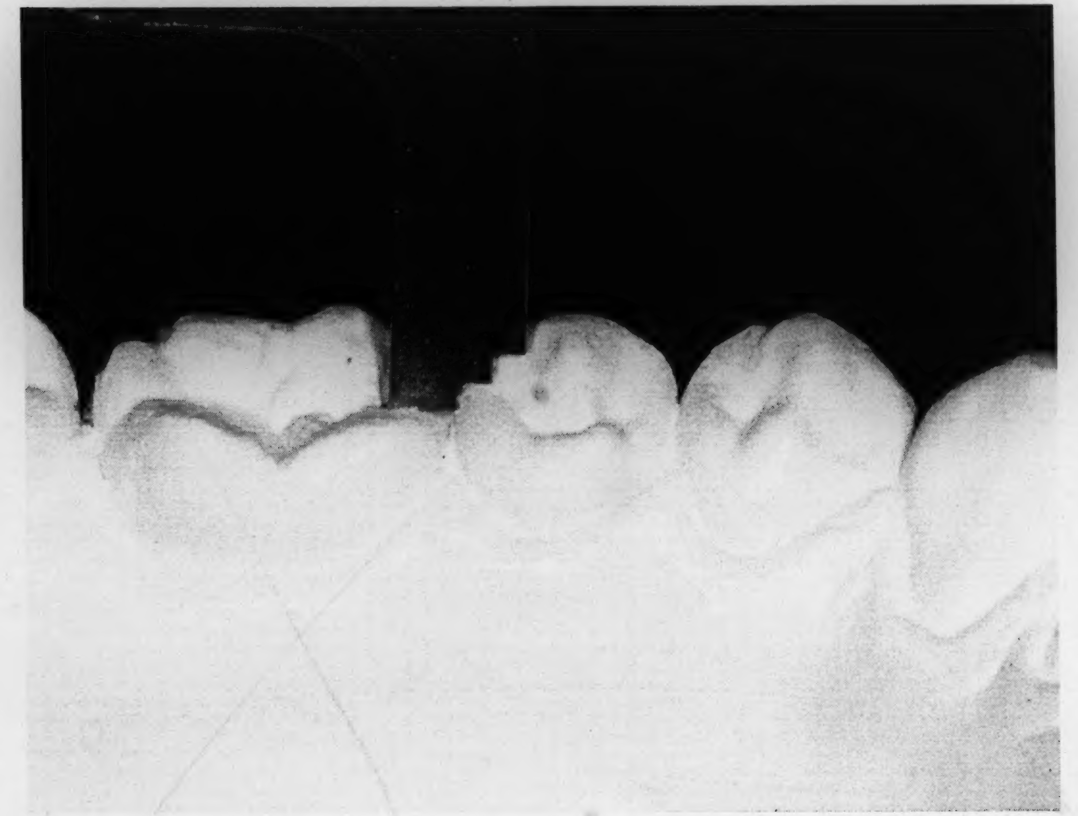
Figure 1.2 American Board of Orthodontics calibrated ruler showing measurement of marginal ridge height discrepancy.



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1.3 Research Objectives

The Gold Standard for treatment outcome assessment is inherent in the subjective agreement of a group of orthodontic specialists. This was the key to validation of the PAR index. [34] There is general agreement in the literature that the PAR index is the Gold Standard tool for analysis of treatment outcome. [63]

The first two objectives of this research paper are to establish the reproducibility of two indices used to measure orthodontic treatment outcome (PAR Index and ABO Score) on the Alberta orthodontic population. Although the PAR Index has previously been found to be reliable and valid it is to be used for other components of this study therefore its proof as a tool within the study is necessary. It will also be compared and contrasted to a second tool. Similarly, a reliability study of the ABO grading criteria will be carried out, as this has not been published to date although its authors state that its use as a tool has been validated and tested for reliability. [33]

The third research objective is to explore in quantitative terms the Standard of Care for regional orthodontic treatment outcomes (in Alberta, Canada). This will be done utilizing the PAR Index to measure pre-treatment and post-treatment dental casts. In essence we will be describing the mean PAR score reduction for a group of casts taken from a representative sample of Alberta orthodontists. It is assumed that the majority of finished cases from a sample of orthodontists will constitute a highly desirable outcome but Richmond et al [32] suggest that the mean percentage reduction should be greater than 70 %. They also suggests that an indication of a practitioner's ability to treat to a high standard is that at least 40 % of cases achieve a PAR score reduction of 22 points, and the number of cases that are "worse or no different" after treatment be negligible (less than 5%).[32] To avoid bias the sample will exclude cases that are finished early for reasons such as hygiene concerns and patient noncompliance. Overall, a random sample of finished cases, from a random sample of Alberta orthodontists, should represent the *standard of care* in the region, and this Standard of Care will be numerically assigned a mean PAR reduction value as well as a percentage PAR score reduction (i.e. degree of improvement over the original malocclusion).

The fourth and final primary objective is to analyze the entire random sample of finished cases (with respect to panoramic radiographs and dental casts) to determine if these cases will be acceptable for passing the Objective Grading Criteria for the ABO Phase III clinical case record examination. This is to be evaluated by the principal examiner using the same calibration materials as those supplied by the ABO to its examination applicants. If the usual outcome of finished cases represents an acceptable level of competence *(to be discovered in objective three)* then logically there should be a large percentage that also passes a theoretical ABO exam, unless the ABO has chosen an unrealistic ideal as its standard instead of an outcome that is more typically achieved by the majority of experienced practitioners.

Subsequent analyses will be completed to examine PAR results relative to sample characteristics such as experience level of the involved specialists (as determined by number of years in practice since graduation from Orthodontic Specialty School). Secondly, we will use regression analysis to determine possible predictors of final PAR Score, PAR score reduction and ABO score from variables gathered during data collection.

1.4 Hypotheses:

Part I: Establish reproducibility of two indices on the Alberta Orthodontic Population.

Proof of the PAR Index as a tool:

H_O 1: Assessment of pre-treatment and post-treatment models using the PAR Index is reproducible (both intra-examiner and inter-examiner reproducibility is present).

H_A 1: Assessment of pre-treatment and post-treatment models using the PAR Index is not reproducible. (I.e. there is a difference among examiners in either intra-examiner or inter-examiner reproducibility).

Proof of the ABO OGS as a reproducible tool;

H_O 2: Assessment of post-treatment models using the ABO criteria is reproducible. (i.e. no intra-examiner or inter-examiner difference present).

H_A 2: Assessment of post-treatment models using the ABO criteria is not reproducible. (i.e. there is a difference among examiners in either intra-examiner or inter-examiner reproducibility).

Part II: Alberta Orthodontist Success/Failure rates using PAR Index as a means of evaluation for Standard of Care:

H_O 3: The mean percentage reduction in PAR score for a randomly selected sample of finished cases from Alberta orthodontists is 70%.

H_A3: The mean percentage reduction in PAR index for a randomly selected sample of finished cases from Alberta orthodontists is greater than 70%.

Alberta Orthodontist Success/Fail Rates using the ABO OGS as a means of evaluation for Standard of Care:

H_O 4: The majority of randomly selected cases (which represent the standard of care for Alberta orthodontists) will satisfy the criteria to pass the occlusal and radiographic analysis section of the ABO phase III exam. (We chose a value of 70 % of the analyzed cases that should pass the ABO).

H_A4: Less than 70% of randomly selected cases from Alberta orthodontists will satisfy the criteria for the occlusal and radiographic analysis portion of the ABO phase III exam (i.e., they would fail that portion of the ABO exam).

This tests the “realistic” ideal against the theoretical Gold Standard (PAR Index).

Chapter Two

Research Paper One

A Comparison of the Reproducibility of the PAR Index and the ABO Objective Grading System in a Random Sample of Orthodontic Patients

2.1 Introduction

There is a growing interest in orthodontics in assessing treatment outcome. A variety of reasons can be cited for this emergent trend. Some researchers desire to analyze outcomes in order to test hypotheses regarding the benefits of two treatment philosophies.[1] Others want to encourage specialists to improve their treatment results by using an objective means of analysis on their own cases which they can then compare to other similar treatment philosophies. [2] Outcomes can also show differences between emerging orthodontic technologies. [3] Use of evidence-based practice and its incorporation into the field of orthodontics will undoubtedly lead the specialty away from basing treatment methods on anecdotal evidence vs. a set of "standards".

The development of reliable and valid measures has become the basis of the outcome assessment movement. [4] The outcome assessment approach has the intention of moving away from the traditional intuitive and unsystematic clinical judgments of decision making. Occlusal indices have emerged as an objective means of analyzing orthodontic treatment results. [5] Shaw et al [5] propose a number of properties for an ideal occlusal index, which include:

- Reliability
- Validity
- Be sensitive to the needs of the patient
- Acceptability to both the public and the profession
- Be administratively simple to operate

- Show sensitivity throughout the scale
- Be amenable to statistical analysis
- Require a minimum of judgment
- Be able to promptly detect a shift of in-group conditions.

Reliability of an occlusal index requires that repeated measures by the same or different raters yield the same result. Jarvinen [6] considers the terms "reproducibility" and "reliability" to be equivalent for our purposes. Reproducibility can best be measured via the Concordance Correlation Coefficient (CCC). [7 8] The CCC is the product of a measure of precision (The Pearson Correlation Coefficient) and a measure of accuracy. [7 8] Validity of an index requires that it accurately measure what it purports to measure. [9] In the case of an occlusal index to determine treatment need or malocclusion extent the gold standard is commonly the expert opinion of a group of orthodontists. [9]

The PAR Index was developed in response to directives to investigate ways to monitor orthodontic standards in the General Dental Service of Great Britain. [9] It is an epidemiologic tool which was validated against a cross-section of dental opinion over a wide selection of cases. [9] If used as intended to assess samples from caseloads rather than individual cases it is a reliable tool to assess performance of practitioners or services.[10] Richmond et al [11] have shown that the PAR Index has good intra- and inter-examiner reliability with intraclass correlation coefficients of .95 and .91 respectively. As stated, the PAR Index has been validated with respect to the opinions of UK dentists and orthodontic specialists on the severity of malocclusion, having a Pearson correlation coefficient equal to .85. [9] Regarding ease of use, Richmond and

Buchanan [12] demonstrated that a group of dentists can easily be trained to record the PAR Index to a satisfactory level. In summary the PAR Index is considered a useful tool for the evaluation of malocclusion severity because of its simplicity, ease of use, portability, and its amenability to different weighting systems based on changing orthodontic opinion. [13]

Using the PAR index, the quality of treatment outcome is measured by quantitative changes in the traits contributory to the malocclusion. The PAR Index has been used extensively to audit orthodontic treatment in Europe. [11 14 15] The mean reduction (which is equated with the degree of case improvement) in PAR score for 220 patients treated by Norwegian orthodontists was 78% [14]. Richmond et al [14] suggest this is evidence that the patients were treated to a very high standard. DeGuzman et al [16] used the PAR score to examine treatment outcome in addition to suggesting that the PAR Index is adequate to approximate malocclusion severity and anticipated treatment difficulty. They showed that the PAR Index is amenable to change by validating it against the opinions of 11 orthodontists and applying different weightings to give it a "United States" (US) weighting.

Another occlusal index has been developed more recently with the same goal of evaluating treatment outcome. The American Board of Orthodontics developed its own occlusal index to score *finished* treatment results.[17] "This objective grading system for assessing the final occlusal results of orthodontic treatment helps to satisfy our mission of establishing and maintaining the highest standards of clinical excellence and to contribute to the development of quality graduate education programs in orthodontics."[17] One of the primary purposes of the ABO Objective

Grading System (ABO OGS) is to allow both ABO examiners and ABO Diplomat applicants to score study casts and panoramic radiographs for the purposes of assessing whether treatment meets the standards set out by the ABO in its Phase III Clinical Case examination. However there have been few studies to date using the ABO OGS on any sample.[3] Since the cases presented for the Phase III Candidate Case Report Examination constitute a highly selected sample it would be expected that these cases would also display a large reduction in PAR score after treatment. This was the reported finding of Dyken et al[18] following analysis of cases which had passed the ABO examination.

Although Casko et al[17] state that the ABO OGS is reliable, to date there are no published studies that independently investigate the reproducibility of the ABO OGS with examiners using the information provided by the ABO. The objective of the present study was to evaluate and compare reproducibility of the PAR and ABO OGS using a randomly selected sample of orthodontic treated cases.

2.2 Materials and Methods

2.2.1 Sample

A sample of 23 cases treated in the graduate orthodontic clinic at the University of Alberta was randomly chosen from the pool of available retention cases. Sample size was calculated using the formula $\Delta = (p-p_o)/(1-pp_o)$ where p = expected intra/inter-examiner correlation (.8) and p_o = no correlation (.5). From this delta value, an n of 23 was chosen based on a master table using a 5% level of significance, 80% power. Records were blinded and scored, in random order, three times by the primary investigator (DD), with at least two weeks separating each scoring session. The same 23 cases were scored independently by two co-examiners once, in random order. Each co-examiner was an orthodontist in Alberta with at least 4 years of experience since graduation, in full time private practice and not practicing in the same office. Each co-examiner received their pre-doctoral and post-doctoral training in different schools. Inclusion criteria included full permanent dentition stage of dental development and availability of pre-treatment and post-treatment models as well as panoramic radiographs of acceptable quality. No attempt was made to prescreen cases for any particular type of malocclusion.

Each examiner was given ample time to study all grading criteria and calibrated themselves thoroughly as instructed using the ABO Calibration Kit. This calibration kit is purchased from the ABO in order that potential applicants can learn to use it and calibrate themselves through a series of provided cases. The ABO OGS kit included information in written form as well as on a CD-ROM with voice-over instruction to enable the investigator to become adequately calibrated in its use. It also included a specific ABO-calibrated ruler. The co-examiners were given as much time as they wanted in order to familiarize themselves with the calibration protocol and become comfortable in assessing completed cases. The ABO recommends that applicants not score their own cases until repeat scoring of the ABO-provided cases is within several points each time; otherwise they suggest re-assessing the scoring rules and repeating the measurements. The ABO examination system scores eight criteria and the final summary score is then used to say if a case will generally pass (less than 20 points are accumulated) or fail (more than 30 points are tallied for occlusal or root positioning errors).

Examiners were also given the initial PAR Index development papers and samples of the recording ruler to practice with prior to the study. No instruction was specifically given regarding the PAR Index other than all applicable scoring conventions, although the chief examiner was available during scoring sessions to answer any questions. No examiners discussed any cases among themselves. Examiners were allowed as much time as they required for scoring sessions with adequate rest breaks to minimize fatigue.

All examiners recorded scores for Pre-treatment PAR, post-treatment PAR and ABO OGS.

2.2.2 Statistical Analysis

The repeated measures Bonferroni pairwise comparison ANOVA (SPSS for Windows version 11.5, SPSS Inc., Chicago IL 60606) was used to evaluate differences between examiner recordings (both intra-examiner and inter-examiner comparison). Reproducibility for intra-examiner and inter-examiner scores was evaluated using the Concordance Correlation Coefficient (CCC). The Concordance Correlation Coefficient was manually calculated by a statistician using the formula reported by Lin et al. [7]

2.3 Results:

2.3.1 Sample Description

The sample consisted of 10 males and 13 females with a combined mean age of 14.03 years (standard deviation 2.21). There were 13 Angle Class I cases and 10

Angle class II division 1 cases. Treatment duration was 23.83 months (standard deviation of 4.25 months).

Descriptive statistics for repeated PAR and ABO OGS scores for each examiner are provided in Table 2.1

2.3.2 Pre-treatment PAR Reproducibility

The first boxplot (Figure 2.1) represents the median and quartile values for the 3 intra-examiner recording sessions as well as the two inter-examiner sessions. It can be seen that both intra- and inter-examiner values fell within a narrow range.

The repeated measures Bonferroni pairwise comparison ANOVA was used to identify differences between examiners. The only significant mean difference was between examination 4 and 5 (between the two co-examiners, MK1 and BN1) where the mean difference (1.696) was significant (p= .032). The CCC for each intra-examiner and inter-examiner values (for PRE-Treatment Weighted PAR) are provided in Table 2.2 (values over .75 indicate excellent levels of reproducibility). Note that for all comparisons of the chief examiner to the other examiners, the 2nd scoring session was used as this session was randomly chosen for the comparison.

2.3.3 Post-treatment PAR Reproducibility

A box plot for the Post-Treatment PAR scores for the primary examiner and co-examiners is provided in Figure 2.2.

For Post-treatment PAR Index scoring, the only significant difference at the $\alpha = 0.05$ level was between the principal examiner's first and third recording sessions. The value was .652 PAR points (p=0.029). CCC values are provided in Table 2.3.

Intra-examiner reproducibility was excellent and Inter-examiner reproducibility was good.

2.3.4 ABO OGS reproducibility

Box plots for ABO OGS scores for the primary and co-examiners are provided in Figure 2.3. For the ABO scores, there were significant differences in recorded mean values between examiners ranging from 6.87 (p=.000) to 8.26 (p=.000) for examiner 1 vs. examiner 3, and 6.02 points (p=.001) between examiner 2 and 3. Figure 2.4 contains a scatter plot illustrating a key finding in the ABO outcome scores. It can be seen that for each final case scored by the principle investigator, examiner 3 gave a considerably higher score. The CCC values provided in table 2.4 give further evidence that there was excellent ABO OGS intra-examiner reproducibility. However, Inter-examiner reproducibility was poor.

2.4 Discussion

Pre-treatment PAR scores were found to be highly reproducible. The lowest CCC values were .877 and .864 for intra- and inter-examiner reproducibility respectively. Although the mean inter-examiner difference was statistically significant, a difference in 1.7 PAR points is not clinically significant. Pretreatment PAR scores can realize a total of over 50 points.

Post-treatment intra-examiner PAR scores were highly reproducible and post-treatment inter-examiner PAR scores had good reproducibility. Although statistically significant, the mean difference between the principle investigator's 1st and 3rd recording (0.65 PAR points) was not clinically significant. In addition, the final treatment outcome scoring using the PAR index is within a narrow band of values, which causes any minor difference in scoring to be magnified.[11 19]

The CCC was developed as a way to statistically evaluate the degree of agreement between repeated measures of the same item. Interpretation of the CCC is similar to the intra-class correlation coefficient (ICC). Although not absolute, a reliability coefficient R value greater than 0.75 is considered excellent agreement (reproducibility), 0.40-0.75 is considered fair to good, and less than 0.4 is poor.[20 21] The CCC values in the present study are similar to but not as high as the ICC values reported by Richmond et al[9] who found reliability values of .95 and .91 for the PAR Index intra- and inter-examiner scores respectively. Buchanan et al[22] also studied a group of 80 casts to examine the reliability of score assessment using the PAR Index. The sample included a wide range of both treated and untreated cases. They found an intraclass correlation coefficient of reliability of .94 for the cases which included both mixed and permanent dentitions.

The ABO OGS intra-examiner reproducibility scores were excellent (CCC of 0.86 to 0.92). However the inter-examiner CCC values were considerably lower with ranges from 0.28 to 0.70. Despite careful self-calibration as specified by the ABO a considerable amount of variation still existed when evaluating completed orthodontic cases. The ABO [17] states that use of its OGS is reliable and valid, and that potential ABO diplomat applicants can use the system to reliably grade their own treatment results prior to submission for examination in the Phase III exam. Clinically a total score point difference of 1-2 points may not make a large difference in outcome. But when the difference between the examiners ranged in value from 6.04 to 8.26 the clinical inference becomes very important. The ABO OGS assigns a pass/fail score with the "cutoff" value set at 20 for a *pass* and 30 for a *fail*. If the assessed score from one examiner is 24, 25 from another, and 32 for the third, some candidates would fail the ABO Phase III CCRE unless all of the examiners agree to introduce a "subjective" component into the system to pass that applicant. In the present sample of 23 cases, Examiner 1 "passed" all but 5 cases using the ABO system. Examiner 2 "passed" all but 6 cases. Examiner 3 however failed 12 cases or 100 % more than the other examiners. While it is understood that the ABO examiners undergo calibration beyond the information package provided by the ABO, there is a potential for loss of consistency over time. Furthermore the integrity of the ABO process as "marketed" in the ABO publications is compromised by poor inter-examiner reproducibility.

The UK (United Kingdom) weighting of the PAR index was used in this study. The reasons for this are that the UK weighting emphasizes the overjet as well as includes a score for the lower labial segment. In contrast the US (United States) weighting excludes the lower labial segment. In a retrospective study by McKnight, Daniels and Johnston [23] the authors found that a significant relapse in overjet and the alignment of the lower labial segment occurs post-treatment and thus the US weighting which ignores this segment is less amenable to use for treatment outcome consideration. However, a potential limitation of using the UK weighting system for the PAR is that the British opinion [9] may not reflect the views of orthodontists in other countries. It could also be argued that the US weighting system [16] is similarly inappropriate for use in Canada. Perhaps a new direction for research would be to validate the PAR index with a new weighting system that is measured against such a large number of North American practicing orthodontists that its utility cannot be questioned.

Patients for inclusion for the present study were randomly chosen. Cases submitted to the CCRE (Phase III) of the ABO examination process are done so to demonstrate skills of the operator (i.e. they are a highly filtered sample) but they may not represent the broad spectrum of treated cases in the practice of that ABO Diplomate applicant. They may in fact be quite different than a group of randomly treated cases from the same diplomat-applicant's case completion files. The inter-examiner reproducibility for highly selected cases submitted to the ABO examination process may be higher than for the sample used in the present study.

If a clinician wishes to use a recognized tool to grade their occlusal outcomes, they might make a decision on which scale to use based on the data from the current investigation. The results from this study suggest that while multiple examiners may agree on treatment outcome of the same cases using the PAR Index they might show significant disagreement when utilizing the ABO OGS. The ABO OGS does appear sensitive and reproducible enough if a single clinician chooses it to assess treatment outcomes and make changes to his/her care delivery in order to achieve improved patient care but they should be aware that other clinicians may not agree with their results. Ideally the operator should be confident that self-audit processes can be completed with assurances of adequate reproducibility in his peer group when using the same assessment tool. However the orthodontist has reasonable assurances based on our data that his own repeated measurements will be reproducible and may use the ABO tool to identify flaws in case outcome and take actions to enhance future treatment. It is still possible that any changes in treatment provision (based on these scores) may be biased or invalid given the likelihood of disagreement among colleagues.

The use of the ABO OGS as a research tool might be flawed as the results from this study suggest that inter-examiner agreement is generally poor when comparing the same sample of case outcomes. As Shaw et al [5] state, reliability of an index is crucial for its proper utilization. If multiple examiners have a poor degree of reproducibility then all assumptions based on that data might be subjective and null.

Finally, one of the largest faults in the ABO OGS may be its utilization as an examination tool by multiple examiners. In deciding if a case will pass the ABO examination it is essential that calibrated examiners have a very high degree of reproducibility on the same cases in order for diplomat-applicants to be fairly evaluated. The data from this study suggests that despite specific calibration protocols multiple examiners may not agree within a close enough range to properly judge treatment outcome. This imperfection in the ABO system should be addressed in order to increase its use in the orthodontic profession.

Treatment outcome is also not to be viewed exclusively in terms of the final result seen in a set of study models. Vig et al [4] have stated that the key advantages of accepted occlusal indices are that they offer reliable, valid, and accurate methods of assessing orthodontic results of dento-occlusal change. However they do not tell the entire story of treatment results [24].Changes in facial profile or cephalometric parameters that reflect the skeletal component of malocclusion are not considered in the occlusal evaluation. It is difficult to measure these changes with validity or reliability because 1) individual biological variation makes discerning between treatment effects, and normal growth and development very difficult; 2) there is no agreement on defined cephalometric goals for treatment; and 3) there are no universally accepted methods to assess changes in facial profile or appearance as an outcome measure. Therefore the continued use of occlusal indices is recommended and may be as optimal as we can hope for at the present in assessing the attainment of desired occlusal outcomes. It must always be kept in mind that the indices do not reflect the multiplicity of effects of orthodontic treatment.

2.5 Conclusions

Based on the results of this study several conclusions may be drawn about the PAR index relative to the ABO OGS:

1. The PAR Index shows excellent reproducibility for intra- and inter-examiner scores for pre-treatment casts.

2. The PAR index shows good inter-examiner and intra-examiner reproducibility for post-treatment cast analyses.

3. The ABO OGS shows relatively good reproducibility for intra-examiner repeat scoring sessions. Inter-examiner reproducibility was poor.

2.6 Tables and Figures

TABLE 2.1: PAR and ABO Means and Standard Deviations for Repeated Intra and Inter-examiner Measurements

N=23	Pre-treatment PAR Mean	Standard Deviation	Post-treatment PAR mean	Standard Deviation	ABO OGS Score mean	Standard Deviation
Researcher Session 1	25.91	7.69	1.87	2.00	23.91	6.38
Session 2	26.87	7.92	2.04	2.05	23.13	5.69
Session 3	26.74	7.51	2.52	2.00	24.52	4.69
Examiner 2	27.30	8.23	2.17	1.95	25.34	5.71
Examiner 3	25.61	7.32	2.13	2.36	31.39	6.51

Figure 2.1 Pretreatment Weighted PAR Scores

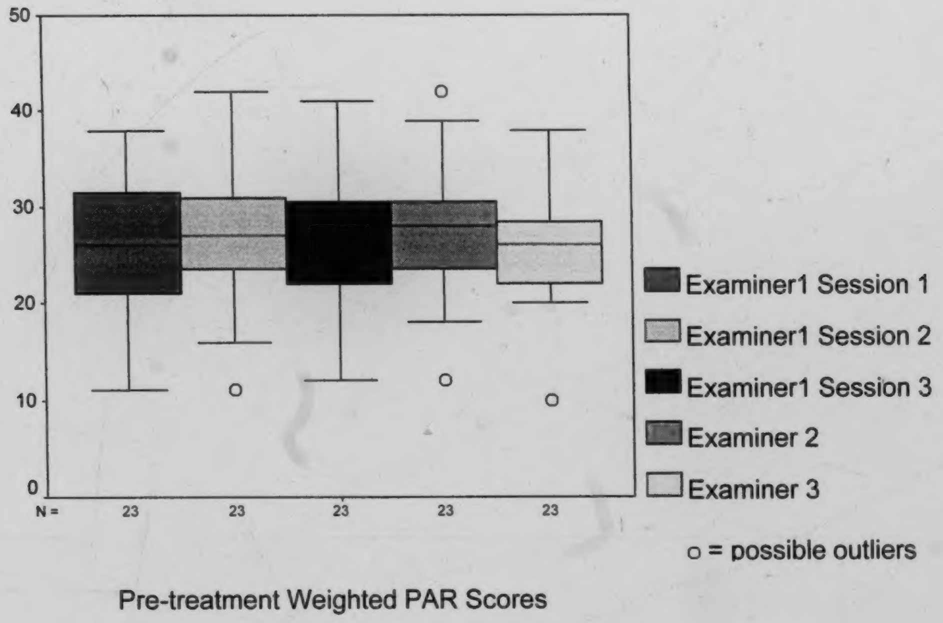
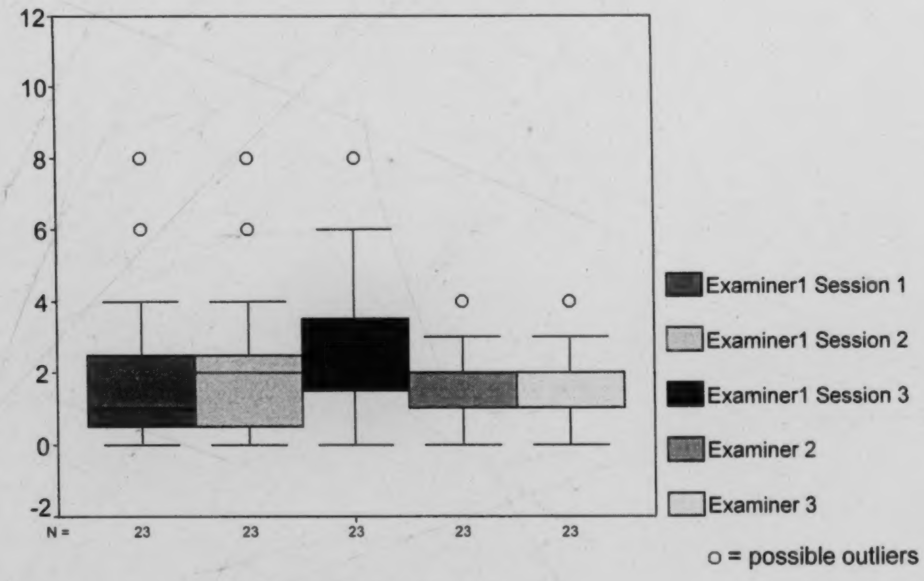


Table 2.2 Concordance values for Pre-treatment PAR scores:

Pre-treatment PAR Score	Examiner 1 Session 1-2	Examiner 1 Session 1-3	Examiner 1 Session 2-3	Examiner 1 vs Examiner 2	Examiner 1 vs Examiner 3	Examiner 2 vs Examiner 3
CCC	**0.9315**	**0.8772**	**0.8920**	**0.8643**	**0.8822**	**0.9283**
CCC across all sessions	**0.900**			**0.8913**		

Figure 2.2 Post-Treatment Weighted PAR Scores



Post-treatment Weighted PAR Index Scores

Table 2.3 Concordance Values for the Post-treatment PAR Score:

Post-treatment PAR Score	Examiner 1 Session 1-2	Examiner 1 Session 1-3	Examiner 1 Session 2-3	Examiner 1 vs Examiner 2	Examiner 1 vs Examiner 3	Examiner 2 vs Examiner 3
CCC	**0.9672**	**0.8461**	**0.8773**	**0.7793**	**0.7497**	**0.8398**
CCC across all sessions		**0.8965**			**0.7895**	

Figure 2.3 Post-treatment ABO Scores

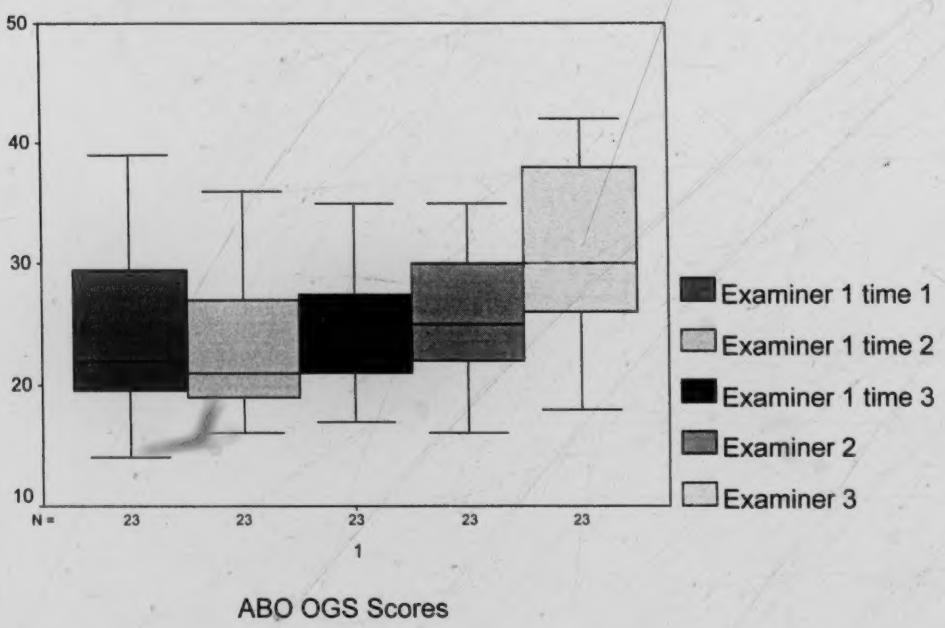


Figure 2.4 Scatterplot of Principle Investigator ABO Scores (Session Two) Compared to Examiner 3 ABO Scores

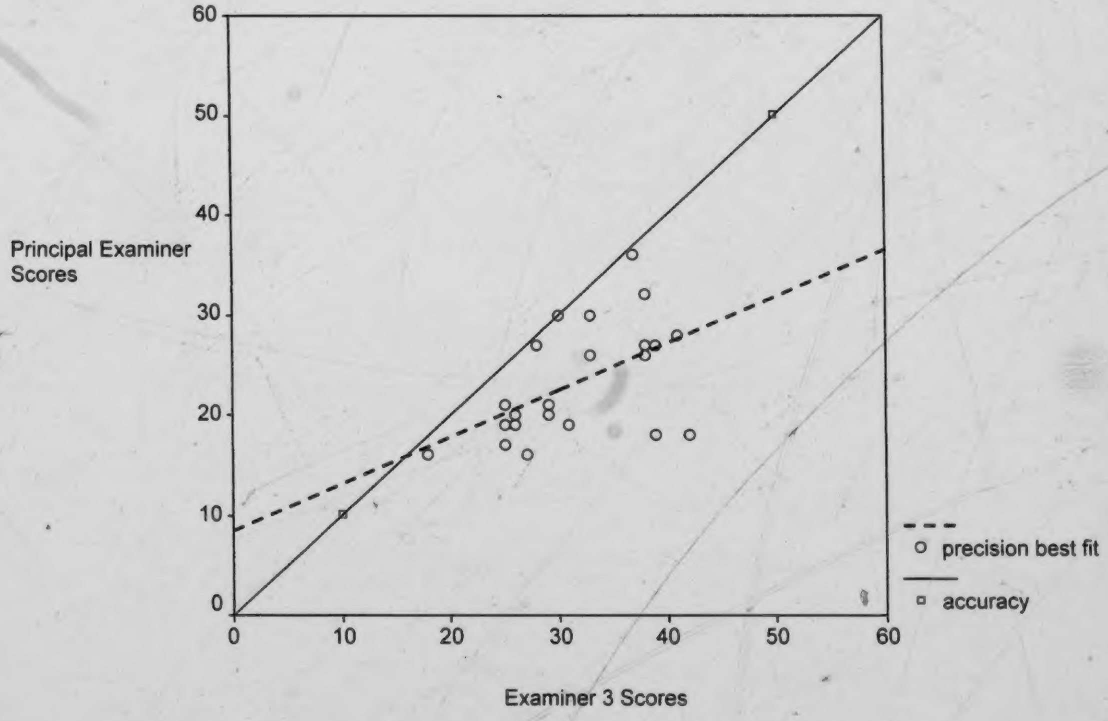


Table 2.4 Concordance values for the ABO OGS Scores:

ABO Scoring Sessions	Examiner 1 Session 1-2	Examiner 1 Session 1-3	Examiner 1 Session 2-3	Examiner 1 vs Examiner 2	Examiner 1 vs Examiner 3	Examiner 2 vs Examiner 3
CCC	**0.9165**	**0.8967**	**0.8565**	**0.7012**	**0.2776**	**0.3590**
CCC across all sessions	**0.8925**			**0.3969**		

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Chapter Three

Research Paper Two

The Standard of Care in the Alberta Orthodontic Population as Tested by the PAR Index and the ABO Objective Grading System

3.1 Introduction

To be considered successful, orthodontic treatment must achieve a number of goals. Objective goals such as Angle Class I molar relationship, ideal incisal overlap, and esthetic tooth alignment need to coexist with the patient's subjective aims of facial attractiveness and minimal treatment time as well as the parent's or patient's notion of reasonable cost. It is unrealistic to expect an ideal outcome for all treated malocclusions. The notion *standard of care* is an important consideration as treatment completion occurs. Did the care provider treat the patient as well as could be expected given the constraints of that individual's malocclusion complexity as well as the practitioner's experience? It is becoming apparent that the public expects an ever-increasing level of competence from members of the dental profession as well as an escalating standard of care. [1]

The American Association of Orthodontists, in its Clinical Practice Guidelines for Orthodontics and Dentofacial Orthopedics [2], lists treatment goals as "optimum dentofacial function, health, stability, and esthetics". This document does not establish a standard of care. The AAO clearly states its position regarding standard of care as "There is no national-based standard of care policy. Standards of care are established locally in each jurisdiction and determined by what is appropriate to the area". [3] *Standard of care* is defined in several ways: It is a statement of actions consistent with minimum safe professional conduct under specific conditions, as determined by professional peer organizations; [4] or it can also mean a statement prescribing the rules, actions, or conditions that direct patient care and these rules may be used to evaluate performance. [5] Therefore, standard of care is defined by the level of treatment outcome being provided by a community of orthodontic specialists and can to some extent vary based on local factors. The competency of an individual practitioner might be evaluated based on whether he/she is capable of consistently meeting the standard of care. It should be possible to equate treatment outcome from a sample of cases with standard of care to a certain degree.

When we consider treatment outcome or standard of care there are several methods of assessing quality of result. We could compare treatment results to Andrew's six keys [6] which give an approximation of how successful the treatment was by comparing it to a sample of cases recognized as not requiring orthodontic treatment at all. Richmond et al [7 8] developed the PAR Index to measure specific occlusal traits on dental models and quantify the amount of malocclusion present. By calculating the PAR score on a set of pre-treatment and post-treatment models it is possible to arrive at a value that reflects the improvement of the treated case (and therefore the standard of care). The improvement of malocclusion may be observed in several ways using the PAR Index; the absolute reduction in score achieved, and the percentage improvement, which reflects the severity of a case prior to treatment. The developers of the PAR Index validated it by applying weightings for each occlusal component so that the objective features of a case more closely matched the opinions of a panel of 74 experts regarding the severity of a malocclusion. Whenever the severity of a malocclusion is discussed the agreement of a group of orthodontists is considered to be the Gold Standard [9], and the PAR Index has itself become the Gold Standard for Outcome Assessment. [10] By Richmond's convention, a high standard of care for a sample is exhibited when the mean reduction in weighted PAR score is greater than 70% and the number of cases falling into his "worse or no different" category (less than a 30% reduction) is negligible (less than 5%).[8] [11] Another indication of good outcomes is when the amount of cases that are "greatly improved" (have at least a 22 point PAR score deduction at the end of treatment) is greater than 40% of the sample. Richmond finally states that a case completed with a PAR score of less than 5 is considered to have an almost ideal occlusion. [8]

Another more recently developed method of measuring the excellence of treatment outcome is via the American Board of Orthodontics Objective Grading System (ABO OGS) which is used to grade finished treatment models and the final treatment panoramic radiograph. [12] The ABO OGS scores eight criteria and the final summary score is used to say if a case will generally pass the ABO Phase III clinical case examination for applicants who wish to be Diplomats of the ABO. It is generally agreed that if less than 20 points are deducted a case will pass that portion of the ABO exam or fail if more than 30 points are deducted for occlusal or root positioning errors. The ABO markets itself with a mission to establish and maintain the highest standards of clinical excellence in orthodontics. [12]

While the ABO OGS was introduced to score "board eligible" (and therefore highly filtered) cases, the objective of this study was to utilize it and the PAR Index to score a randomly selected sample of treatment outcomes from the province of Alberta in order to compare these tools as methods of identifying a realistic standard of care. Another objective of the present study was to provide data on a North American "unfiltered" sample with respect to a reasonable expectation of outcome values for either PAR score reduction or ABO OGS scores, and to determine if dental relationships at the end of orthodontic treatment are within the ABO's limit for passing the phase III examination.

3.2 Materials and Methods

3.2.1 Sample Collection

Approval for this study was obtained from the Health Research Ethics Board, University of Alberta.

This study was based on the population of orthodontic cases treated by private practice certified specialists in the province of Alberta, Canada. Those orthodontists with less than 3 years of experience were excluded because their number of finished cases would be very small at this early stage in their career. A sample of 22 of the 54 eligible subjects was randomly selected using a random number generator. A total of 10 finished cases were randomly chosen from the active retention files for each orthodontist. Sample size requirement for this study was estimated using the following formula, based on a hypothesis that 70% of the sample would pass the ABO grading criteria.

Frequency distribution:

$N= (Z_\alpha)^2(1-p)/a^2p$ where p=expected % who will pass the ABO OGS (in this case, 70)

a = level of accuracy (+/- 10%)

Z_α=95% confidence interval

$= (1.96)^2(1-.70)/(.10)^2(.70)$

$= 3.84 * .30/.01 * .70$

$=1.152/.007$

=165 models (cases) is the minimum number that should be examined to provide statistical validity.

Four of the initial 22 orthodontists chosen for participation did not respond to (four) attempts by telephone, fax, and mail to be included in the study. Two telephone calls were made initially. Each telephone call was allowed three days for a response followed by one fax and one letter asking for the orthodontist to contact the principal researcher. Each time the researcher called, he spoke with a staff member who assured him that the message would reach the orthodontist in question. Unfortunately no response was ever received. The researcher then again randomly selected participants until four more orthodontists agreed to participate. In total, approximately 18% of the selection group declined participation.

Information letters were sent to each participating office and followed up with a personal telephone call to explain the study in detail. The principal examiner then visited each office and chose 10 cases at random which had been debanded within the previous 12 months. Selection criteria included cases with complete pre-treatment and post-treatment records. The records had to include properly finished study models and a post-treatment panoramic radiograph. Exclusion criteria included cases in which treatment was discontinued due to poor oral hygiene or parental wishes. However no randomly selected cases were excluded in this study due to the exclusion criteria.

As a random sample, a wide variety of cases was selected and was considered to be representative of the orthodontic population in Alberta. No attempt was made to gather a minimum number of cases for each malocclusion type required by the ABO Phase III examination categories.

Records were blinded and randomly scored by the principal investigator using the PAR Index (UK weighting system) on both pre-treatment and post-treatment models and using the ABO OGS on the post-treatment models along with their accompanying post-treatment panoramic radiograph. The special "PAR Index Ruler" was purchased from the United Kingdom and used to increase reliability and ease of measurement. The ABO provided information in written form as well as on a CD-ROM with voice-over instruction to enable the investigator to become adequately calibrated in its use. The ABO also included its own specifically calibrated ruler for use in scoring the OGS. Calibration procedures as recommended in the ABO instructions were carefully followed.

3.2.2 Statistical Analysis

Overall PAR score reduction, weighted PAR score reduction (United Kingdom weighting), and percentage PAR score reduction were calculated. ABO scores were calculated for each case as well. 2 x 2 contingency tables with Chi-Squared tests of independence (SPSS 11.5 for Windows, SPSS Inc., Chicago IL 60606) were used to sort results by amount of PAR Index reduction for separation into categories of improvement while defining the number of cases that would pass the ABO Phase III examination. This then was used to accept or reject the post-hoc hypothesis that ABO Pass/Fail and PAR Score reduction are independent. In other words, the Chi-Squared test of independence is used to compare the expected number of cases that would pass the ABO exam with the [expected number of] cases that would have [at the same time] accomplished a predetermined benchmark of PAR Score reduction.

3.3 Results

The sample consisted of 180 cases from a broad spectrum of malocclusion types and extraction plans. Descriptive values for the sample are provided in Table 3.1. The population consisted of 119 females and 61 males with a mean age of 14.32 years (S.D. 5.36). Mean treatment time was 24.64 months (S.D. 6.21).

Descriptive statistics (mean and standard deviation) for the outcome measures are provided in Table 3.2. The pre-treatment mean weighted PAR Score of 34.05 indicates a large deviation from normal and perhaps a great need for treatment. The post-treatment weighted mean PAR Score of 4.07 indicates an overall high standard of treatment delivery.

PAR Score percentage reduction was plotted on a frequency histogram to examine for normal distribution (Figure 3.1). It is evident that the frequency distribution is heavily skewed i.e. a large number of cases display a high Percentage PAR Score reduction which in turn is another indicator of performance to a high standard of care. Forty-four out of 180 cases showed a 100% PAR score reduction.

Table 3.3 sorts cases that had at least a 70% PAR Score reduction by whether they satisfied the conventions to pass the ABO OGS. From the table, 163 out of 180 cases showed at least a 70% improvement in UK-weighted PAR Index score. Only 17 cases did not achieve this considerable improvement. This translates into 90.6% of the sample exhibiting what Richmond refers to as a "high standard of treatment", illustrating that the standard of care as defined by PAR score reduction is very high in

Alberta. However 52 of the cases (31.9%) that achieved this degree of PAR score reduction would not have passed the ABO criteria as they had at least 30 points deducted for occlusion or root positioning errors on the ABO OGS (Chi-Squared test p value 0.000). In general, out of 180 cases, 65, or 36% of the total sample would have failed the ABO phase III objective grading system i.e. 36% would not equate to PAR in terms of a high standard of treatment. The Chi-Squared test of independence is used to compare the expected number of cases that would pass the ABO exam with the expected number of cases that would at the same time accomplish a greater than 70% reduction in PAR score. The p value of 0.000 leads us to reject the null hypothesis that the ABO Pass/Fail and this large reduction in PAR Score are independent.

Table 3.4 divides cases with a weighted PAR reduction of at least 22 points (i.e. cases that are "greatly improved") into similar ABO pass/fail categories. It was found that 142 cases (out of 180) exhibited a weighted PAR Score reduction of at least 22 points (Chi-Squared test p value 0.386). In percentage terms 78.9% of the random sample showed a 22 point or greater PAR score reduction. This value far exceeds Richmond's suggestion that at least 40% of a sample show great improvement.

A distinction of cases that were ideally finished by Richmond's standards is found in table 3.5. From the table, 109 of 180 (60.5%) cases displayed a post treatment weighted PAR score of less than 5. By Richmond's convention these cases would be considered to have an ideal occlusion. 17 of these 109 cases were not within the ABO's limit for passing the phase III board examination (Chi-Squared test p value 0.000).

Finally, an examination of cases in this sample population that fell into the "worse or no different" category for PAR Score reduction revealed that there were none. Richmond states that this category contains cases that achieved less than a 30% reduction. The minimum percentage PAR Score reduction from the study sample was 39.4%.

3.4 Discussion

The PAR index and ABO OGS are limited in that quantitative scores do not reflect changes in facial profile, skeletal foundation, and cephalometric parameters. These variables are difficult to measure due to a variety of reasons [13]. Individual biologic variation causes difficulty in sorting out changes due to normal growth and development from those due to orthodontic treatment. There is little universal agreement on what constitutes ideal cephalometric goals at treatment completion. Similarly there are no ways to measure facial profile as an outcome variable that would be agreed upon as well as show acceptable reliability and validity. Thus the only way to measure *many* of the effects of orthodontic treatment is with an occlusal index.

While the PAR score was initially developed to assess or set the standard of orthodontic treatment in a publicly funded health care system [8], this could mean that there is a limitation to interpreting results from this study as the sampled population came from private practices in a non-publicly funded region. It is possible that a different standard of care is expected when treatment is paid for with "private" vs. public funds.

The mean percentage PAR Score reduction in our study was 87.9 %, in indication of the high standard of treatment delivery overall in Alberta. A comparison of the mean percentage reduction in weighted PAR score against other studies is provided in table 3.6.

As is seen in the table the present study generated treatment outcome findings comparable to and exceeding that of other sample populations. The outcome value of almost 90 % mean PAR Score reduction is considerably higher than some others have reported [7 14]. However all patients in the present study underwent comprehensive orthodontic treatment, by orthodontic specialists, with full upper and lower banding which may explain the better results. No two samples in the table are identical therefore direct comparison is not possible and this may be another limitation of the results. Despite this the comparison to previous research does suggest that the standard of care is very high in Alberta.

Barring factors outside of their control it is in the best interest of both specialist and patient for the very best occlusal characteristics to be exhibited at the completion of treatment. As Linklater and Fox [15] state, deterioration over time occurs despite the best outcomes. Although their sample showed an overall PAR reduction of 68.6% immediately post-treatment the PAR reduction was only 55.5 % when reevaluated at a mean of 6.5 years post-retention. Cases in which both arches were treated did fare better in terms of less occlusal deterioration beyond the retention period than single arch treatments.

In a study analyzing ABO diplomat cases for PAR score reduction, Dyken, Sadowsky and Hurst [16] found that graduate student-treated cases achieved an 81.7 % (+/- 15.3%) PAR score reduction while the ABO-accepted cases showed a higher PAR reduction of 87.9 % +/- 9.5%. They explain this difference by the fact that the pre-treatment PAR values of ABO-accepted cases had initially more difficult malocclusions to treat. Treatment time for the Board-accepted cases in their study was significantly longer (mean 31.7 month's duration) than in the present study (24.64 months). It is possible that a more severe malocclusion may require a longer duration of treatment however the iatrogenic and psychosocial costs of increased treatment time for the patient are difficult to estimate. It is difficult to speculate how much more time it would take to transform a "good" outcome into a "Board-Quality" result. Treatment time in the present study was similar to that found by Kelly and Springate (22 months), and the overall PAR Score reduction was very similar at 89%. [17]

In contrast to the present study the percentage PAR score reduction for patients treated by the general dentist population sampled in Scotland was only 59%.[18] In fact 15% of the cases they studied were considered to be "worse or no different" than when they began treatment, a dramatic difference from the Alberta orthodontic sample which had zero percent of cases in this category. This result implies that the cases treated by general dentists in Scotland fall far short of Richmond's conventions for a high standard of treatment. In a study similar to this, Fox et al [14] found that qualified orthodontic practitioners achieved significantly better results than those without any orthodontic qualifications. PAR scores decreased by 75.5% for the orthodontic specialists compared to 61.9% for the general dentist sample (using fixed appliances). Radnzic studied the effectiveness of salaried (not fee-for-service) orthodontic practitioners and found a mean of 74.9% for the PAR Score reduction. [19] He also showed that dual-arch fixed appliance treatment produced the best results compared to treatment such as with removable appliances in terms of PAR score reduction.

It is apparent that the PAR index is limited in its ability to distinguish fine details in dental relationships with respect to an "idealized" outcome. It was expected that an 89% PAR score reduction would translate into a very high number of cases also passing the ABO OGS system but this was not the case in the present study. Sixty-five out of 180 cases (36.1%) did not pass the ABO scoring system. In fact the number of cases that would be considered "ideal" by Richmond with respect to final occlusion was 109 out of 180 in the present study (60.5%) however 17 of these cases (16 %) did not achieve a low enough score to pass the ABO OGS. This strongly agrees with the findings of Poulton, Baumrind and Vlaskalic [20] who suggest that the PAR Index may not be sensitive enough to detect minor irregularities in a finished case.

For comparison to the present findings one study examining results of treatment using the ABO OGS was found. [21] Yang-Powers et al [21] found that of the cases treated in a graduate orthodontic clinic only 18 of 92 (19.6 %) would have passed the ABO examination. They also studied cases submitted by ABO diplomats and found only 46.9% would have passed the ABO OGS however these cases were a mixture of those presented before and after institution of the new grading system. The mean ABO OGS score was 45.54 for the university group and 33.88 for the ABO diplomat group. These results are dramatically different (worse) than those found in the present study where the mean ABO score was 25.16 (s.d. 9.31). In the study by Yang-Powers et al [21] the findings indicate that the ABO group had lower (better) scores than did the university group, explained by the fact that the ABO group was highly selected and chosen for its good outcome. In comparison to the present study findings then it would seem that the general orthodontic population of Alberta is treated exceedingly well and fares even better than the ABO group of Yang-Powers et al [21] (if we accept that the ABO OGS is a valid measure of the standard of care). However when we consider our findings of ABO OGS scores versus the PAR Score reduction, there is an obvious disparity.

The PAR and ABO OGS scoring systems differ in a number of ways. While the PAR index measures both pre-treatment and post-treatment models to score the improvement obtained in a malocclusion, the ABO OGS only scores the final result based on an assumption that treatment was ideal, deducting points for errors in the specific occlusal criteria. Although the PAR Index and the ABO OGS are both meant to evaluate treatment outcome, the PAR was developed to measure any set of models at any stage of treatment. In contrast the ABO system was developed to measure highly selected cases which ABO applicants submit in order to pass an examination. Applicants are given calibration kits with instructions on how to score their own treatment results with the intention that cases that are likely to fail the examination will not be submitted.

In reality the two scoring systems give an indication of the orthodontic standard of care for a population sample from two different perspectives; The PAR score indicating how much improvement has occurred in each case and the ABO OGS showing the occlusal inadequacies remaining after treatment.

The Legal Standard of Care is not considered to be unreasonably high, but it is a very subjective issue upon which reasonable people can differ. [22] The ABO OGS is ultimately based on a very high standard or "utopian" level of occlusal aspirations from a highly selected population while the PAR ("Peer" Assessment Rating) Index is based on a value set by analyzing a group of general orthodontic outcomes. The outcomes from an unbiased sample should reflect the best possible treatment outcome given the complexities of patient compliance, desires, needs, and growth and development. As long as an orthodontist is in possession of the same skills and learning as the average member of his peers and performs treatment with due diligence then the Standard of Care as seen in the PAR Score reduction should be fulfilled. In fact, being Board Certified is irrelevant in determining if Standard of Care was breached. [23]

Despite ABO recommendations regarding use of its Diplomat status, it is a common perception even within the specialty that ABO-certified orthodontists are seen as being better than non-certified individuals.[24] [25]

In the current study 65 ABO failures out of 180 cases does not necessarily mean that the Alberta patients were not treated to a high standard of care. For a practitioner to produce high standards of treatment the mean percentage reduction for his cases must not only be high (greater than 70%) but the percentage of cases having been greatly improved should also be high (greater than 40%). The number of cases falling into the "worse or no different" category after treatment should be negligible (less than 5%)[8]. Our findings indicate that 90.6 % of the cases had at least a 70% reduction in PAR Score, 78.79% were "greatly improved", and no case was found to be "worse or no different". This illustrates that the standard of care as defined by PAR score reduction is very high in Alberta particularly since the sample was unselected. The Chi-Squared test for independence for two of three categories leads us to reject the null hypothesis that the PAR Score reduction and ABO Pass/Fail categories are independent. However the Chi-squared p value of 0.386 for the crosstabulation results in the "Greatly Improved" category would suggest accepting the null hypothesis.

It is unclear from the present study results alone what would be a satisfactory number of cases that should pass the ABO examination in order to exhibit the high standard of care sought-after by the ABO. More research utilizing randomly chosen populations is recommended to further bracket an acceptable range of outcomes for the ABO values. The mean ABO score for our sample group was 25.16 which is approximately 5 points below the limit for passing the ABO examination, suggesting that the average Alberta finished case would still satisfy the ABO's accepted limits. This statement then agrees with the general PAR Score evaluation; equating to a high standard of care delivery in the province.

3.5 Conclusions

Based on the results of this study of a randomly chosen patient population the following conclusions can be drawn:

1. When considering the standard of care for orthodontic treatment, the American Board of Orthodontics Objective Grading System is based on a standard of treatment outcome that is generally not equivalent to a large reduction in PAR score alone.

2. The ABO OGS is a finely detailed scoring tool which might single out finishing inadequacies that the PAR index is unable to detect. Seventeen out of 109 "ideal cases" (using the convention of a PAR Score less than 5 as an indicator of an ideal occlusion) were not within the limits for passing the ABO phase III examination.

3. The Alberta orthodontic population is treated to a very high standard of care. Overall an 87.98 % reduction (T-test p = 0.000) in PAR score was obtained for the randomly chosen sample. 60.5 % of the sample would be considered ideal occlusions after treatment, while 78.89 % of cases studied would fall into the "greatly improved" category. None of the cases would be considered "worse or no different" after orthodontic treatment.

4. One hundred and fifteen out of 180 cases or 64% satisfied the conventions for passing the ABO OGS component of the ABO phase III examination. Based on the mean ABO score of 25.16, on average, the cases treated in Alberta would pass the ABO examination.

3.6 Tables and Figures

Table 3.1 Sample Description

	N=180	Percentage of total group
Mean Age (years) + standard deviation	14.32 (5.36)	
Treatment Time (months)	24.64 (6.21)	
Males	61	33.9
Females	119	66.1
Extraction Treatment (none)	109	60.6
Extractions (Upper first bicuspids)	18	10
Extractions (Upper and lower first bicuspids)	45	25
Other extraction plan	8	4.4
Angle Class I malocclusion	46	25.5
Angle Class II.1	118	65.6
Angle Class II.2	11	6.1
Angle Class III	5	2.8

Table 3.2 Outcome values for PAR Score and ABO score

n=180	Mean	Standard Deviation
Pre-treatment Unweighted PAR	19.92	5.98
Pre-treatment Weighted PAR	34.05	9.97
Post-treatment Unweighted PAR	2.39	2.05
Post-treatment Weighted PAR	4.07	4.26
Unweighted PAR score Reduction	17.53	5.68
Weighted PAR Score Reduction	29.98	9.76
Percent Weighted PAR Score Reduction	87.98	12.24
Post-treatment ABO score	25.16	9.31

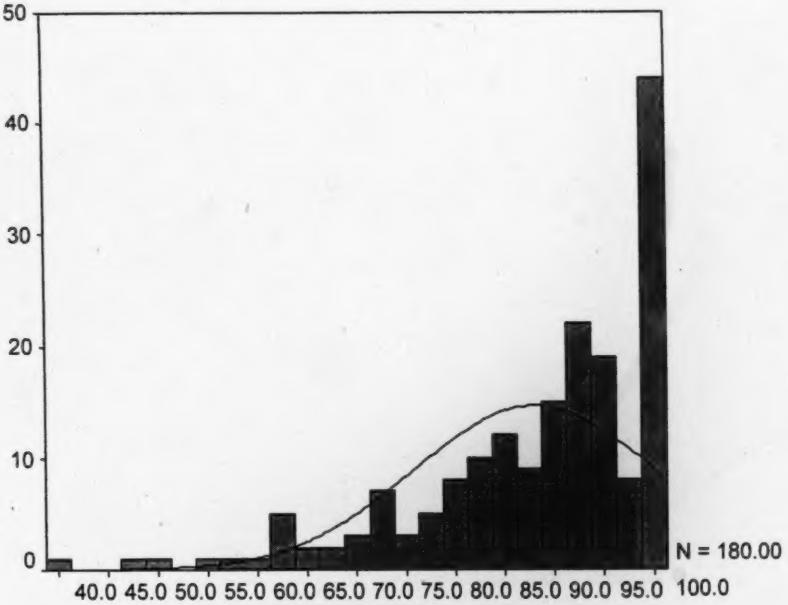

Figure 3.1 Percentage PAR reduction frequency histogram

Table 3.3 2 x 2 Contingency Table Results for "High Standard of Treatment" Cases vs. Number of Cases in the ABO Pass/Fail Category (Chi-Squared test p=0.000)

	Cases with <70% PAR reduction (Expected Value)	Cases with >=70% PAR reduction (Expected Value)	**Totals**
ABO Fail	13 (6)	52 (59)	**65**
ABO pass	4 (11)	111 (104)	**115**
totals	**17**	**163**	**180**

Table 3.4 2 x 2 Contingency Table Results for Weighted PAR "Greatly improved" cases vs. cases in the ABO Pass/Fail Category (Chi-Squared test p=0.386)

	Cases with <22 point weighted PAR reduction (Expected Value)	Cases with >=22 point weighted PAR reduction (Expected Value)	**Totals**
ABO Fail	16 (14)	49 (51)	**65**
ABO pass	22 (24)	93 (91)	**115**
totals	**38**	**142**	**180**

Table 3.5 2 x 2 Contingency Table Results for Ideal Cases vs. Cases in the ABO Pass/ Fail Category (Chi-Squared test p=0.000)

	Cases with => 5 point post-treatment weighted PAR (Expected value)	Cases with <5point post-treatment weighted PAR (Expected value)	**Totals**
ABO Fail	48 (26)	17 (39)	**65**
ABO pass	23 (45)	92 (70)	**115**
totals	**71**	**109**	**180**

Table 3.6 Comparison with other study findings for Weighted PAR Score Reduction

	n	% Reduction
Present study: 180 patients randomly chosen from 10 private practices in Alberta	180	87.9
O'Brien et al 1995[26]; 250 class II division 1 cases (OJ>5mm), treated by orthodontic graduate students.	250	77.1
Fox et al 1997[14]; 250 consecutive cases examined from 41 practitioners.		
General dentist treated cases	92	49.8
Orthodontic specialist treated cases	158	70.0
Turbill, Richmond, and Wright 1999 [27] 1527 consecutively treated cases evaluated from the Dental Practice Board of England and Wales (sampled both general practitioner and specialists)	1527	47.59; Removable Appliance tx only: 39.08% Dual arch appliance treatment: 63.26%
Richmond et al 1992[7 28]		
1010 cases treated in the GDS of England and Wales (both fixed and removable appliance treatment)	1010	55
Cases treated only with dual arch fixed appliances	196	71.4
Richmond and Andrews 1993 [11] Patients treated by 6 Norwegian Orthodontic specialists, 120 consecutively treated and 100 randomly chosen.	220	78 %
O'Brien, Shaw and Roberts 1993[29] 1630 cases consecutively treated in 17 hospital based orthodontic departments in England and Wales	1630	75.5
Dyken, Sadowsky and Hurst 2001[16] 54 Board-Accepted cases treated by various ABO certified orthodontists	54	87.9

51 cases consecutively treated by Alabama orthodontic graduate students	51	81.7
Kelly and Springate 1996[17]; 20 consecutively treated dual-arch fixed appliance cases, from each of 10 orthodontists working in the GDS of England.	200	89.0
Mascarenhas and Vig 2002[30]		
165 consecutive patients from Ohio orthodontic graduate students, compared against:	165	77.5
143 consecutively treated orthodontic private practice patients (from Ohio)	143	80.9 (no significant difference detected between groups).
Willems et al 2001[31]: 292 “final examination” cases, representing all types of malocclusion, treated by 18 Belgian orthodontic graduate students	292	79.1
Buchanan 1996[32]	82	74
41 consecutive cases treated using the Begg appliance in the United Kingdom	41	65
41 consecutive cases treated using the pre-adjusted edgewise appliance	41	81

3.6 Reference List

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Chapter 4

Research Paper Three

An Examination of Factors Involved in Treatment Outcome of the Alberta Orthodontic Population

4.1 Introduction

Objective treatment outcome assessment has become an integral component of medicine and is rapidly emerging as a primary issue in orthodontics.

The quality of outcome or *degree of success*, according to Bergstrom et al [1] can be viewed in terms of:

1) Reduction of treatment need
2) Stability of outcome
3) Patient satisfaction/fulfillment of initial desires/expectations
4) Parent satisfaction with esthetics, fees, duration of treatment
5) Amount of residual deviation from ideal tooth relationships.

The level of occlusal refinement provides one basis for objective evaluation of treatment. Adherence to Andrew's Six Keys [2] with correct crown angulations, crown inclination, rotations, spacing, overbite, overjet and posterior interdigitation allow achievement of several treatment goals including optimum dental esthetics and stability.

The PAR Index [3] in a short period of time, has become the gold standard for evaluating the outcome of treatment or a malocclusion. [4] The American Board of Orthodontics Objective Grading System (ABO OGS) was recently introduced as an occlusal index to score finished treatment results. [5] It is understood that the difficulty in achieving an ideal occlusion increases as the severity of the original malocclusion increases [6]. The final result or outcome of treatment is influenced by many factors such as age of the patient, gender, cooperation, distance from the operator, amount of chair time utilized, and whether fixed or removable appliances are used for treatment.[7-9] However, it has not been established how much each factor contributes to the occlusal treatment outcome. Tahir et al [10] reported that treatment time was associated with post-treatment PAR score which contradicts the findings of Kelly and Springate.[8]

A search of the literature identified only one study which examined outcome quality using the newly developed ABO scoring system.[11] The authors reported that the choice of bracket system and patient age can influence the quality of treatment as measured by ABO results.

The aim of the present study was to examine occlusal treatment outcomes in the Alberta orthodontic patient population with respect to what specific factors might contribute to the quality of outcome as measured with two occlusal indexes, the PAR Index, and the ABO OGS, as well as what might help in predicting treatment time.

4.2 Methods and Materials:

This study design and methodology were accepted by the Health Research Ethics Board, University of Alberta in Edmonton, Canada.

4.2.1 Sample collection

The sample for this study was taken from the post-treatment records of 18 randomly selected orthodontists in private practice in Alberta, Canada. Orthodontists with less than three years of practice were excluded from the sample. Ten completed case records were randomly selected from the active retention files of each orthodontist, providing a total sample of 180 cases. The sample size was based on a calculation from a previous study in which 180 cases were required to provide statistically robust data to evaluate the Standard of Care inAlberta.[12] Exclusion criteria were cases with incomplete pretreatment or posttreatment records. Records had to include study models and a panoramic radiograph taken after appliance removal to assess root angulation.

Patient records were blinded prior to analysis. The dependent variables; Pretreatment PAR score, posttreatment PAR score and ABO OGS were determined for each case. Percentage PAR Score Reduction was calculated as (pretreatment PAR score - posttreatment PAR score)/pretreatment PAR score x 100%. Treatment time was measured in months.

For the purpose of analyzing possible outcome-contributing factors, data recorded in addition to these dependent variables included the following seven independent variables:

- Patient gender.
- Patient Age at treatment start and finish.
- Active treatment duration in months.
- Orthodontists' years in private practice since completing specialty school.
- Case dental classification, using Angle's Classification System.
- Amount of crowding in the upper and lower dentition, in millimeters.
- Type of extractions (if required as part of the treatment plan).

The PAR index [3] has seven components: Upper anterior segment, lower anterior segment, left buccal occlusion, right buccal occlusion, overjet, overbite, and centerline. These components are measured from the dental cast using a specially developed PAR index ruler that is see-through for increased reliability and ease of use. The individual scores for the various components are weighted (multiplied) according to the United Kingdom-weighting factors and summed to prdocue the PAR score. The weighting factors for overjet, overbite, lateral occlusion, and centerline are 6, 2, 1, and 4 respectively. A PAR of zero indicates perfect alignment and occlusion and higher scores (rarely above 50) indicate increasing levels of irregularity. The change in the total PAR score from pretreatment to posttreatment casts reflects the degree of improvement and the success of orthodontic treatment. A malocclusion is defined as "greatly improved" if the final PAR value is at least 22 points less than the initial PAR Score. [13] [14] The authors also state that a high standard of care is exhibited if the overall reduction is at least 70% less than the pretreatment score.

The ABO OGS [5] analyzes eight components of the occlusion found on dental casts and a posttreatment panoramic radiograph. These components are alignment, marginal ridge height, buccolingual inclination, occlusal contacts, occlusal relationships, overjet, interproximal spacing, and root angulation (measured on the radiograph). These are only measured on the final treatment models and pretreatment records are not scored. The examined components are the key areas in which the ABO found that applicants for ABO diplomate status had the most difficulty in past years. For each component, an analysis of the cast or radiograph is made using a specially developed measurement ruler and points are deducted according to a scoring key. No weighting is applied to each component. The total deductions are simply summed. Regarding the ABO OGS, there is no "passing score" per se. It is acknowledged that a case with less than 20 points deducted will generally pass the

ABO Phase III examination while a case with more than 30 points deducted will fail it. The ABO states that the OGS for the dental cast grading section is only one component of the Phase III diplomate examination and other factors such as treatment goals, diagnostic abilities, and rationale are also considered in whether a case passes or fails the examination.

4.2.2 Statistical Analysis:

Independent samples t-test for Equality of Means (SPSS version 11.5 for Windows, SPSS Inc., Chicago IL 60606) was used to compare means of the outcome values by gender. Multiple regression analysis and ANOVA were used to model and determine if any of the investigated factors were predictive of the outcome values. Bonferroni pairwise comparison was used to analyze differences in outcomes according to Angle's classification. Unless otherwise stated, values were considered significant for all statistics at the $\alpha = 0.05$ level. Primary outcome variables were *Treatment time* (months), *ABO Score*, *Raw PAR Score, and Percentage PAR Score Reduction.*

4.3 Results

Descriptive data for the sample and independent variables are provided in Table 4.1.

Using the Independent t-test for equality of means, no gender differences for Percentage PAR Score Reduction (p= 0.116), ABO OGS (p= 0.225) and Treatment Time (p= 0.723) were identified. Because there were no statistically significant differences between these main outcome variables we used blended gender groups for all further analysis.

Descriptive statistics for measured variables are provided in Table 4.2 and descriptive statistics for the sample according to Angle Classification are provided in Table 4.3.

Statistically, there was no significant difference between Angle Class groups for the mean ABO Score or the Percentage Par Score reduction. However, the Bonferroni pairwise comparison ANOVA did find a significant difference (p=0.001) in treatment time between Class I and Class II division 1, and Class I and Class II division 2 cases. Class I treatments required a mean treatment time of 21.60 months, while class II.1 cases required 25.46 and class II.2 required 28.18 months. The mean treatment time for class III cases was 25.20 months. Because the sample size for Class III cases was small and may lead to biased interpretation of results a nonparametric Kruskal-Wallis ANOVA was performed on the same data set. Results confirmed what the Bonferroni comparison found i.e. that treatment time was the only variable that was significantly different among the various Angle Class groups.

Descriptive statistics for the sample related to extraction treatment are provided in Table 4.4. Independent samples t-test for equality of means found that there was a significant difference in treatment time (p=0.005) with slightly increased treatment time (2.64 more months) for cases requiring extraction compared to non-extraction. There were no statistically significant differences in ABO score, Posttreatment PAR score, or Percentage Reduction in PAR score (p= 0.573, 0.426 and 0.897, respectively) between extraction/non-extraction groupings.

Treatment time was first examined as a primary outcome variable. The variation in treatment time was partially explained by *dental class, operator years of experience, patient age,* and *extraction/non-extraction treatment* (p=0.001, 0.001, 0.001, and 0.033, respectively. The univariate ANOVA found a modest R^2 of .241 for these combined factors, meaning that 24.1% of the treatment time variability can be accounted for by those four factors. However, years of experience and patient age had negative associations with the treatment time, implying that an increase in patient's age or operator experience had the effect of reducing overall treatment time.

When the ABO Score was analyzed with respect to the seven independent variables, only *years of experience* and *dental class I* were found to be significant predictors with R^2= 0.071 (p= .002 and .036, respectively). The association was positive i.e. more experience did not predict lower ABO scores. The univariate ANOVA picked dental Class I to be significant versus all other classes combined.

The analysis of Post-treatment PAR score (UK weighting) revealed a positive association (R^2 = 0.058) with the only variables significant being *patient age* and *amount of lower crowding* (p=0.014 and 0.024, respectively). In other words, although the two variables only predict approximately 6% of the variability in final PAR score, one might say that an increase in patient age or amount of lower crowding could lead to worse final PAR scores, and therefore less ideal final treatment.

Finally, the percentage PAR Score reduction was analyzed with the same univariate ANOVA model. In this analysis, only *patient age* was significant ($p = 0.017$) with an $R^2 = 0.032$. Only 3.2 % of the variation in percentage PAR reduction was negatively associated with age of the patients.

A secondary analysis was done to examine the relationship between the primary outcome measures. Using the Pearson Correlation Coefficient and a significance value of $p=0.01$, it was found that Percentage PAR reduction had a negative association with the ABO score ($r = -.550$). However, Percentage PAR reduction had a larger negative correlation with the post-treatment PAR score, as would be expected ($r=-.920$). Post-treatment PAR score had a positive correlation with the ABO OGS score of $r= .628$. This is to say that a larger final PAR score might be associated with a larger ABO score, and a large percentage reduction in PAR score will also mean a lower final PAR score. However, a large percentage PAR reduction is only moderately correlated with a lower final ABO score.

4.4 Discussion

The Percentage PAR Score Reduction in this Alberta sample (87.98 +/- 12.24) was similar to the Percentage PAR Score reduction reported in the Dyken et al [15] sample of ABO-accepted cases (87.9% +/- 9.5%). Treatment time for the Board-accepted cases in their study was significantly longer (31.7 months) than in the present study (24.64 +/- 6.5 months). Their study also found that posttreatment PAR score and treatment time were associated. Yang-Powers et al [16] also reported longer treatment time (36.47 +/- 16.52 months) in their sample of ABO cases. Differences in treatment times between the present study and the ABO case studies may relate to the present study inclusion criteria of a minimum 3 years of experience and higher average years of experience (the mean experience in the present study was 17 years). Most orthodontists challenging the ABO application process are in the early stages of their career. Although the present investigation did not identify an association between practitioner experience level and Percentage PAR Score Reduction (only patient age was significant), it is hoped that greater years of experience may allow achievement of similar outcome with shorter treatment time. A possible explanation for longer treatment times may relate to extra attention taken by orthodontists in preparation to take the ABO examination, without measurable difference in outcome. Turbill et al [17] found that longer treatments did not result in a clinically significant lower residual malocclusion than did treatments of average duration.

Treatment outcome in the present study was considerably better than reported by Yang-Powers et al [16] however we examined only orthodontists with a minimum of 3 years of experience in private practice while their study examined cases treated by university graduate orthodontic residents. In the university study group only 18 out of 92 or 19.2 % would have passed the ABO Phase III examination while in our group almost 64 % would pass the Phase III examination.

The Percentage PAR Score Reduction identified in the present Alberta sample (87.98 +/- 12.24) was similar to that reported by Wagner and Berg [18] (88%), and Kelly and Springate [8] (89%). Consistent with the present study findings, Kelly and Springate found no relationship between treatment time and PAR score change. Mean treatment time was 22 months, a finding similar to the present study.

The present investigation identified a weak association of post-treatment PAR scores to the amount of lower crowding present at the start of treatment. Regarding treatment time and extractions, Holman and Nelson [19] found that a group of patients who had four premolars extracted required a mean of 29.7 months of treatment while a comparison group without any extractions required 26.0 months. In that study, the group who had extractions had significantly higher pre-treatment PAR scores as well as higher scores for maxillary tooth discrepancy and greater overjet scores than the non-extraction group. Overall the PAR reduction was 79.4% in the extraction group and 77.6% for the non-extraction group, a difference that was not statistically or clinically significant. The present study found a similar result; that cases in which extractions were carried out as part of the orthodontic treatment plan required a mean of 26.24 months for treatment, compared to 23.60 months of treatment for the non-extraction treatment. In addition to the extraction or non-extraction treatment, our study also found that patient age, dental class, and years of operator experience had some predictive capability regarding the variation in treatment time.

Holman and Nelson[19], using the decrease in weighted PAR as the dependent variable found only 15% of the variability in amount of PAR decrease explained by extraction and Angle classification. When they used Percentage PAR reduction as the dependent variable they found that their model explained 21% of the variance and they identified operator experience and pre-treatment PAR as the main significant factors. It is apparent that almost 80 % of the variability in PAR reduction was explained by factors not included or considered in the model. In the present study a univariate ANOVA using Post Treatment PAR score as the dependent variable did not identify significant contributions from operator experience, number of extractions, treatment time, Angle Class or amount of upper arch crowding. There was a weak association with lower incisor crowding and patient age explaining only 5.8% of the variation in Post-Treatment PAR. The final product of orthodontic treatment; the alignment, overjet and other occlusal components could be related to many factors not considered or easily studied such as individual operator preferences for finishing and detailing the occlusion, individual variation in tooth morphology and patient compliance.

Regarding the level of experience as a factor in treatment outcome, it is difficult to speculate why experience might predict quality of outcome. In this study, operator experience contributed to the variation in treatment time, and final ABO score. One would expect that when finely detailed finishing arch wires are placed the quality of the result has a lot to do with the practitioner's experience. However it is possible that as the specialist becomes increasingly busy this disallows some of the time available for detailing the occlusion, negating an improved result. It is also possible that newer, less experienced orthodontists may replace poorly positioned brackets rather than spend a lot of time bending wire for finishing and detailing the occlusion. As an orthodontist ages, they may become less idealistic about treatment expectations and outcomes as frustration with patient compliance thwarts much of their enthusiasm for achieving the ideal result. When practitioners embrace a new technology they may change general attentiveness to bracket position in order to achieve the better outcome they hope will occur due solely to that new system. [11] Or, newer technology invariably occurs at a higher price to the specialist and thus more emphasis on proper bracket position may influence the outcome despite the level of experience of the operator. It is intuitive that as orthodontists develop more experience there would be a concomitant increase in Percentage PAR score reduction, or a decrease in the ABO Score. This was not found with the variables analyzed in the present study. It is probably more likely that each operator has his or her own opinions on when to end treatment based on what is a reasonable outcome for each individual patient given their subjective needs and the specialist's desires. In a similar finding, Turbill, Richmond and Wright [17] found that orthodontic qualifications simply had no significant effects on outcome.

This study was limited in that it did not examine facial esthetics, cephalometric radiographs, or iatrogenic factors such as decalcification, gingival recession, and root resorption in considering outcomes. This is a common limitation and complaint of most indices of treatment outcome.[19] Model analysis was also done with dental casts that were fabricated usually immediately after appliance removal and it is difficult if not impossible to comment on long term stability or settling of even the best treated cases. Patient satisfaction was not measured with either the PAR Index or the ABO Objective Grading System, and functional considerations were also not included in analysis of success. Only dental casts and panoramic radiographs were assessed. It is now known that panoramic radiographs are generally unsuitable for precise evaluation of the location or shape of roots when assessing mesiodistal angulation for the ABO OGS [20]. The United Kingdom weighting system was used for the PAR index which may not be easily generalized to other populations due to regional differences in opinion on the severity of malocclusion traits such as overjet and midline deviations.

It is possible that the patient demographics as well as those of the practitioners are regionally different from other populations and this study may be limited in its discussion to this region of North America.

The ABO OGS only scores treatment outcome and not malocclusion severity or treatment difficulty. These two factors may influence some orthodontists to accept a less than ideal result in certain instances that would preclude them from showing a still reasonable finish to the ABO for critique. The true measure of experience, maturity, and competence of an orthodontic specialist may lie in the degree of improvement he obtains for his patients tempered by the individual complexities of that patient's malocclusion, desires, and other unknown factors. Eliminating all negatively influential variables from the treatment equation is all but impossible which is why it might be unreasonable to expect perfection in every orthodontic treatment result. It is a professional obligation that each orthodontist, after consideration of all tangible and intangible factors will do the most benefit with the least risk of iatrogenic effects.

Using the Pearson Correlation Coefficient, Percentage PAR Score reduction had a negative and somewhat weak relationship with final ABO score, and a very strong negative correlation with the final Post-treatment PAR score as would be expected. There are no studies similar to the present one with which to compare our results but it is speculated that although the degree of PAR improvement should have a higher predictability for the ABO Score there were factors at play in the outcome that were not considered in the regression models such as parental/patient wishes, operator subjective judgment, and individual preferences for finishing and detailing a case. In addition, it is speculated based on previous research [12] that the ABO OGS may be able to discern occlusal details much more discriminately than the PAR Index. More research is recommended to further outline as many factors that influence orthodontic treatment as possible and work should be done to develop acceptably reliable and valid measures for these other factors.

4.5 Conclusions

Within the context of this investigation the following conclusions can be made: This study examined 180 randomly chosen orthodontically treated cases from Alberta.

1. Treatments involving extraction required a mean of 2.64 more months for treatment than those without extractions, a statistically significant difference.

2. No significant difference was found between the extraction group and nonextraction group in terms of final PAR Index score, Percentage PAR score reduction, and post-treatment ABO Objective Grading System Score.

3. Overall PAR Score Percentage reduction for the study group was 87.98 %.

4. Mean ABO OGS Score for the study group was 25.16

5. 115 out of 180 cases or 64% of the study group would pass the ABO Objective Grading Criteria.

6. Orthodontist's experience, Angle classification, extraction versus nonextraction treatment, and patient age were significant in prediction of the variation in treatment time.

7. Very little of the variation in final ABO score, post-treatment PAR score, and percentage PAR score reduction could be predicted using the variables studied in this paper. It appears that while we may find some small association of the studied factors with our outcome variables, overall they may not be clinically meaningful in terms of predicting treatment success.

Table 4.1 Data Description:

Mean Age 14.32 years (S.D. 5.36)	**N=180**	**Percentage of total group %**
Males	*61*	*33.9*
Females	*119*	*66.1*
Extractions (none)	*109*	*60.6*
Extractions (Upper first bicuspids)	*18*	*10*
Extractions (Upper and lower first bicuspids)	*45*	*25*
Other extractions	*8*	*4.4*
Angle Class I	*46*	*25.5*
Angle Class II.1	*117*	*65.6*
Angle Class II.2	*12*	*6.1*
Angle Class III	*5*	*2.8*

Table 4.2: Outcome Variables and Factors

n=180	Mean	Standard Deviation
Pre-treatment Unweighted PAR	19.92	5.98
Pre-treatment Weighted PAR	34.05	9.97
Post-treatment Unweighted PAR	2.39	2.05
Post-treatment Weighted PAR	4.07	4.26
Raw PAR score Reduction	17.53	5.68
Weighted PAR Score Reduction	29.98	9.76
Percentage PAR Index Reduction	87.90	12.24
Post-treatment ABO score	25.16	9.31
Orthodontist's Experience (years)	17.0	7.78
Treatment Time (months)	24.64	6.21

Table 4.3: Results by Dental (Angle) Classification:

Dental Class	Mean ABO Score	Standard Deviation	Mean Percentage Par Score Reduction	Standard Deviation	Treatment Time (months)	Standard Deviation
I (n=46)	22.89	10.093	86.36	15.019	21.60	6.45
II.1(n=117)	25.50	9.000	89.10	10.52	25.46	5.68
II.2 (n=12)	28.55	8.524	87.27	12.20	28.18	6.99
III (n=5)	30.60	7.021	77.82	18.77	25.20	5.40

Table 4.4 Extraction VS Non-extraction Comparison

Extraction vs Nonextraction comparison		**Mean**	**Standard deviation**
Extraction Group (n=71)	ABO Score	24.84	9.64
	Posttreatment PAR Score	4.38	3.72
	Percentage PAR score reduction	88.12	10.65
	treat time (months)	**23.60**	**5.76**
Nonextraction Group (n=109)	ABO score	25.65	8.82
	Posttreatment PAR score	3.86	4.57
	Percentage PAR score reduction	87.88	13.21
	treat time (months)	**26.24**	**6.55**

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Chapter Five

Discussion
And
Recommendations

5.1 General Discussion

Part of being a professional is the ongoing task of monitoring one's own treatment to ensure adequate meeting of patient needs as well as practitioner desires. The two are often not coincident. [1] It is also becoming apparent that in order to maintain a high standard for the public's protection some form of peer review is necessary. Peer review may have a negative connotation associated with it as in the case when a complaint from the public is investigated. However there are other needs and uses for peer assessment. Ensuring the monitoring and adequate utilization of limited public health resources is a key use in some countries. [2] Peer review is also used to analyze the best output that a practitioner has accomplished in order to garner support from his peers i.e. the achievement of Board Certification.

For the ABO certification, approximately 2000 members or roughly 20% of the American Association of Orthodontists have become board certified. It is unclear why more specialists do not become board certified but it may have to do with cost of application, extensive time required for preparation, or lack of perceived benefit.

When considering the final outcome of treatment, Spiedel states that the courts have ruled a bad result does not, by itself, constitute negligence. [5] In summary, "a physician is not an insurer of a cure or a good result of his treatment. He is only required to possess the skill and learning possessed by the average member of his profession in good standing in his locality, and to apply that skill with learning and care".[5]

The ABO OGS only scores treatment outcome and not malocclusion severity or treatment difficulty. These two factors may influence some orthodontists to accept a less than ideal result in certain instances that would preclude them from showing a still reasonable finish to the ABO for critique. Perhaps the ABO should accept that the true measure of experience, maturity, and competence of an orthodontic specialist may lie in the degree of improvement he obtains for his patients tempered with keeping treatment duration as short as possible. The ABO is seen by some as the guardian of the orthodontic specialty. It is expected that conscientious practitioners probably already perform periodic self-audits to maintain or improve upon a high standard of treatment. Eliminating all negatively influential variables from the treatment equation is all but impossible. Today's demanding practice environments include the public's desire for the orthodontic profession to ensure that competency is only going to increase. This does not mean that we have to establish minimally acceptable levels of treatment outcome for our colleagues to attain. It should mean that we accept a certain measurable, objective standard of care that is exhibited by the specialists of each region. It is a professional obligation that each orthodontist, after consideration of all visible factors will do the most benefit with the least risk of iatrogenic effects. As previously stated there is no national based standard of care policy. The American Association of Orthodontists has stated that standards of care are established locally in each jurisdiction and determined by what is appropriate to the area.

Although esthetics is an important part of treatment goals Birkeland et al [6] found that improvement in patient self-esteem (after satisfaction with dental appearance increased significantly) did not correlate with treatment changes visible in the PAR score. The key finding in this study was that both children and parents rate pleasant dental esthetics as an important factor for psychosocial wellbeing, yet we are frustrated by the inability to score such traits on an outcome assessment with universal agreement on desired values. The authors found that the assumption that orthodontic treatment improves facial appearance and self worth is difficult to prove. 80% of children and 92.5% of parents would under similar circumstances undergo treatment again. One in three parents felt that orthodontic treatment positively influenced their child's social skill and one in five thought it would have a positive influence on their child's career choice and choice of a mate. Treatment significantly increased children's satisfaction with their own dental appearance and they were overwhelmingly satisfied with orthodontic treatment results. The study confirms that the perceived benefit of esthetic improvement is the most frequent reason for treatment, and children and their parents rate pleasant esthetics as an important part of psychosocial wellbeing. As the incidence of orthodontically treated people increases and dental appearance improves the relative importance of esthetics compared to occlusion changes. Minor detailing of the occlusion may be forced to take a back seat to the esthetic demands of the future orthodontic patient.

5.2 Limitations

It should be noted that since patients were randomly chosen for this study, they were not consecutively treated. This introduces potential bias because of the exclusion of altered or abandoned treatments. However, selection was not based on choosing a good outcome. The primary objective was to see the average treatment outcome for cases that were finished in good faith by the specialists.

Another limitation may be that the Alberta patient population is different from other samples in terms of racial background, mean age, and other demographic factors which may make generalizations difficult. Similarly, the myriad of different individuals treated prevent any specific PAR Index or ABO Score conclusions from being made based on one specific type of malocclusion. It is important to keep in mind that two cases with the same PAR score may present with entirely different initial malocclusions, treatment need, treatment difficulty, and complexity. [7]

The PAR Index and the ABO OGS are the sum total of many subcomponents that may lead to large errors when even a few elements are omitted or incorrectly scored. Another limitation of using the UK weighting system for the PAR is that the British opinion may not reflect the views of orthodontists in other countries although a similar argument can be made against using the American weighting system for the PAR Index.[8]

The PAR index provides a method for measuring the occlusal change observed on pre- and post-treatment models only. Similarly, the ABO OGS only measures final models and panoramic radiographs. The grading systems were not designed to examine the broader effects of orthodontic treatment including its effect on facial appearance, skeletal change, functional and psychosocial improvement, or iatrogenic damage. [1 7] The PAR Index also has several limitations for occlusal measurements; it does not record incisor torque, posterior alignment, or changes in arch dimensions. [9] The inability to measure incisor inclination may lead to an evaluator perceiving an overjet reduction as being excellent but not able to tell if this was due to an excessive amount of incisor tipping to accomplish that outcome.

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Hand articulation of models does not exactly reproduce true occlusion due to the missing temporomandibular joints, neuromuscular components and attributes of occlusion. Regarding buccal occlusion, the present study found many cases in which a slightly imperfect result was penalized. From the scores for both posttreatment PAR and ABO OGS it is clear that it is difficult to achieve perfect buccal occlusion in most cases. This may be due to the fact that the score for buccal occlusion is sensitive to even minor deviations from what is considered normal. A mild variant (more than 1 mm) from full interdigitation is immediately scored as sub-optimal on either scoring system. Secondly the scoring system includes the entire zone from canine to last molar even if these teeth were not involved in treatment due to late eruption, operator preference, lack of need, etc. This negatively affects both PAR score and ABO OGS. Finally this penalty makes no allowance for any occlusal settling which may improve the buccal interdigitation over time. Some authors have recommended that in order to increase validity of this segment exclusion of second and third molars from the recording and inclusion of a degree of latitude or allowance for a certain amount of deviation from full interdigitation may be allowed. [7] It is possible that variations in hand-articulation of the dental casts alone may be the reason for mild deviations from full intercuspation.

ABO examiners regularly meet to calibrate themselves but it is clear from this study that there can certainly be discrepancies between examiners despite clearly following the grading guidelines.

In certain cases of treatment a practitioner may intentionally rotate molars forward to achieve space closure or good occlusal contact. This however may result in alignment score deductions, root proximity deficiencies and marginal ridge height discrepancies according to the ABO OGS.

Richmond showed that personal audits on a large enough sample are worth completing to see if the mean percentage PAR score reduction is greater than 70%. [10] However it is admitted that the PAR index is less useful for analysis of a few individual cases as there may be limited agreement due to subjective opinions. [11] It also may be more difficult to learn by non-orthodontic staff than first thought. [12]

Although extremely complex surgical cases, cleft lip/palate, and cases of extreme oligodontia were not excluded from this study they were not present in the random sample. The PAR Index is not recognized as a valid measure of treatment outcome in these cases because while it will measure improvement in tooth irregularity the main treatment objective may not be the same as for a typical orthodontic patient.

Richmond and Daniels [13] showed that the clinical judgment of treatment outcome is influenced by the practitioner's country of residence, payment methods, practice environment, and practitioner's experience. This reinforces the notion that the PAR Index and ABO Scoring system may both be vulnerable to subjective bias despite efforts such as repeated calibration exercises to make them more objective.

Another basic flaw with both the PAR Index and the ABO OGS is that neither system considers patient happiness with the esthetic outcome of treatment. One study found that the major reason for patients seeking orthodontic-surgical treatment was "problems with biting and chewing" followed by "dissatisfaction with facial appearance" [14]. Similarly the score obtained from a set of finished models says nothing about the change or improvement in function sought after by the patient. Although a skeletal dysplasia may manifest itself in dento-alveolar conditions that a patient is keenly aware of, the esthetic improvement and not the occlusal change is the most frequent reason that general orthodontic patients seek treatment [6]. Both children and parents ranked pleasant dental esthetics as being very important for a healthy psychosocial well-being.

Both the PAR Index and ABO OGS fail to consider if there is any remaining discrepancy between the centric relation and intercuspal position or if there are non-working side contacts and protrusive contacts. Some authors feel that these are key criteria for deciding if an occlusion is acceptable [15-17].

Despite these limitations the PAR Index has been increasingly used in audit and research studies as shown in this paper [18] [19] [20] [21-23]. It is still considered valid to use occlusal indices for resource allocation and planning, promotion of treatment standards, identification of prospective patients and informed consent. [24]

The cases selected for the CCRE Phase III of the ABO examination process are done so to demonstrate the diagnostic, treatment planning, and clinical skills of the operator but they may not represent the broad spectrum of treated cases in a practice. They may in fact be quite different than a group of consecutively treated cases from the same individual. Treatment outcome cannot be solely evaluated based on the final result seen in a set of study models. The overall treatment efficiency, environment, and chair-side manner used to treat the patient should also be considered.

Finishing and detailing the occlusion in order to provide “Board Quality” results is intuitively going to take longer than merely “straightening the teeth”. There is an ethical dilemma of a practitioner keeping a patient in treatment for longer than the patient desires or requires for a satisfactory result in order to justify the ABO OGS requirements. One researcher suggests that this calls into question the “integrity” of the ABO as being a guardian of the specialty of orthodontics. [25]

A major limitation of both the PAR Index and the ABO OGS are that they are based on the underlying assumptions that malocclusion and its features are associated with a detrimental effect on health at some point in the future. This has not been conclusively demonstrated. [26]

5.3 Consideration of the ABO OGS Criteria

From the study it is evident that the orthodontists in this study experienced deficiencies in each scoring category of the ABO system. However the greatest mistakes made overall were in the *Alignment* category indicating perhaps more time should be spent paying attention to minor details of tooth position. However close behind this were the *Marginal Ridge* and *Buccolingual Inclination* categories. It is possible that the finished casts did not reflect adequate settling of the occlusion. It is well known that the occlusion continues to settle for an extended time into the retention period. [27]

As esthetics is one of the main reasons for seeking orthodontic treatment it is clear that alignment should be as good as possible. The mean points deducted indicate there is room for improvement. It is unknown why alignment is not perfect in every case although it is suspected that most of the deficiencies occurred in the first and second molar region as these were mentioned as being the key problems in previous ABO examinations [3]. One reason for this is the possibility that practitioners did not routinely include second molars in their orthodontic treatment, or perhaps a bracket or band positioning error occurred. It could be that in order to obtain a solid posterior occlusion the amount of derotation of the upper first molars may cause an alignment score deduction between the premolars and the first molar, or between the first and second molars. Intentional over-rotation of posterior teeth may well be part of a valid treatment plan.

The next worst component was marginal ridge discrepancy. Again, bracket positioning error may contribute to this score deduction as well as lack of care or attention in final detailing of the occlusion. It does not take into consideration the degree of settling of the teeth after appliance removal. The ABO implies that creation of even adjacent marginal ridge heights is periodontally desirable as this will help to create even interproximal bone, but there is no proof in the literature that this would be the case. It is broadly documented that orthodontic tooth movement enhances the risk of loss of alveolar crestal bone height. [28]

Buccolingual inclination errors often occurred in the second molar teeth, both upper and lower. It is possible that these teeth were not incorporated into the orthodontic appliance, or it may have been too difficult to see these teeth well enough to place proper torque into a wire during finishing. Recognition of minor inadequacies of posterior torque may be complicated by patient position, lighting, insufficient understanding of the amount of torque built into an appliance or inability to correct it due to appliance design.

Regarding Occlusal Contacts, the number of deductions was less than the first three categories but still accounts for approximately 9% of the total mean ABO score. Again, it is possible that a considerable amount of occlusal settling may occur subsequent to appliance removal and that this number could reasonably be expected to decrease if re-measured in several months. Regarding balancing side interferences that present on the final treatment models we do not know if they will spontaneously disappear as the occlusion continues to settle in the post-treatment retention period.

Finishing and detailing of the occlusion can correct mild deficiencies for example in occlusal contacts or buccal-lingual inclination if the practitioner is willing to have the patient in treatment long enough for final wires to also accomplish this.

However it has been suggested that we should minimize the time patients spend in fixed orthodontic treatment in order to reduce the long term periodontal risks of increased gingival and periodontal inflammation. [29 30]

In terms of Occlusal Relationships, it appears that some specialists can not completely obtain a solid Angle class I relationship (Or Class II relationship if the original treatment plan called for this goal). This may be due to loss of posterior anchorage, patient compliance issues, or other reasons. It is also possible to have an ideal anterior esthetic arrangement of the teeth but have a less than ideal posterior relationship due to an upper and lower tooth size discrepancy or Bolton Ratio. One must keep in mind that Angle classification is unreliable as a diagnostic measure. [31]

It appears that *Overjet* is relatively well treated in the Alberta patient population. This is to be expected as orthodontists, parents and patients will usually push for treatment to continue as long as a larger than ideal overjet is seen intraorally.[32]

As discussed, orthodontists in this study group are relatively proficient at closing *interproximal spaces*. It is possible that some of the space noted was residual orthodontic band space that may close in the settling phase of retention.

Lastly, *Root Angulation* received a relatively higher amount of deducted points. Although the panoramic radiograph is not ideal for assessing mesial-distal root position or root shape [33 34], the ABO uses it to ensure that roots are parallel and not touching adjacent roots. It is possible that the orthodontists are less cognizant of root position even when looking at a panoramic radiograph as other factors such as space closure may take precedence. Paralleling roots in extraction spaces is thought to assist in long term stability. However, the method of scoring root position is flawed when utilizing this type of radiograph. [33] [34] Root abnormalities that are clearly visible on periapical films often appear normal on panoramic films. [34] Despite this the ABO continues to utilize the panoramic film for root assessment. The clinical implication of this is that if using the panoramic radiograph to diagnose and treat root parallelism the operator may create excessive convergence or divergence of the roots instead. The ABO implies that there are functional and periodontal advantages to having the roots of teeth lined up according to its recommendations but this has not been proven in the literature. In fact, it was found that even a markedly mesially inclined tooth is no more prone than an upright tooth to lose periodontal support on the mesial surface. [35] Several authors have found that the benefits of uprighting teeth may not justify the risks involved. [29] [30] [35]

Another example of cases in which ABO criteria might not accurately judge a treatment result are those in which tooth mass discrepancies (Bolton problems) may result in good posterior occlusion but inadequate anterior relationships i.e. overjet. Or, cases with perfect overjet but inadequate posterior occlusion may also occur due to a tooth size discrepancy between upper and lower teeth. It is possible that cases selected for the ABO grading process are biased in terms of having an ideal Bolton tooth size ratio. While some authors showed that in cases exhibiting moderate tooth size Bolton discrepancies it was possible to achieve a reasonable occlusion with a low PAR score, this was only studied in a mock tooth setup. [36] An acceptable class I molar relationship was obtained as well as a reasonable overjet and overbite. They stated that only in severe situations of tooth-size discrepancy will the final occlusion (as evaluated in a setup) be affected to some extent. Freeman, Maskeroni and Lorton [37] examined 157 patients accepted for treatment in an orthodontic residency program. They found in this sample that the range and standard deviations for tooth-size discrepancies were well outside of Bolton's 2 SD. When the buccal occlusions of cases with tooth-size discrepancy were analyzed it was noted that they were rarely ideal. Thus it appears that a large percentage (30.6% in this case) of patients present with relative tooth size discrepancies that could potentially cause problems in attaining an optimal occlusal relationship. In other words the case treatment goals and results may be adversely affected which would compromise final score using either the PAR Index or the ABO OGS.

5.4 Discussion of Research Results:

In chapter two of this paper the reproducibility of the two indexes was investigated. With respect to the ABO OGS scores, the first and third examiner and the second and third examiner differed dramatically in mean ABO scores. Clinically a deduction point difference of 1 or 2 points may not demonstrate a large difference in outcome. But when the difference between the examiners ranged in value from 6.04 to 8.26 the clinical importance becomes clear. The ABO OGS assigns a pass/fail score with the "cutoff" value set at 20 for a *pass* and 30 for a *fail*. If the mean score is 24 for one examiner, 25 for another, and 31 for the third, then someone is going to fail the ABO Phase III CCRE a significant number of times unless all of the examiners agree to introduce a "subjective" component into the system to pass that applicant. This would be counterproductive to the entire concept of an "Objective" Grading System. In our study sample of 23 cases, Examiner 1 passed all but 5 of the 23 cases using the ABO system. Examiner 2 passed all but 6 cases. Examiner 3 however failed 12 cases or 100 % more than the other examiners. Thus the objectivity becomes suspect due to the amount of "drift" among examiners. However, the study is limited perhaps by the number of examiners that were tested. It is speculated that there would be a considerably higher degree of drift between the same examiners over time, as the ABO examiners do meet for several days prior to grading cases in order to become recalibrated with the same system used in previous years. It has been found that outcome judgment is significantly affected by the country and payment methods, practice environment, and experience of the practitioner. [38] It must be remembered that even when guidelines are published and adhered to as conscientiously as possible it is the examiners themselves that may still be unreliable. There is no guarantee despite the amount of calibration exercises and orthodontic training that results will be reproducible in a narrow range due to differences in perception, experience, aptitude, and regional biases regarding severity. [39]

Chapter Three of this paper examined the Standard of Care in Alberta as seen utilizing the PAR Index and the ABO OGS. The overall Percentage PAR reduction was 89%, a finding similar or better than other studies have reported on randomly selected populations. [14 40-42] In a study from the United States a lower reduction range of 73%-78% was found [1]. A rather low percentage reduction in PAR score was found in the general dentist population of Scotland where they achieved only a 59% reduction.[43] 15% of the cases studied were considered "worse or no different" after treatment. In another study comparing dentists to specialists found that specialists achieved a mean reduction of 75.5% compared to the 61.9% for the general practitioners. It appears that method of payment did not affect outcome in one study as the mean reduction was still 74.9% for salaried orthodontists and this was a blend of single and dual-arch fixed appliance treatment. Mascarenhas and Vig [44] found that there was no statistically significant difference in the results obtained from orthodontic residents compared to a group of practicing orthodontists with many years of experience (77.3% PAR reduction vs. 80.9% respectively). It is evident that a standard of care is learned early in specialty training which may not diminish or increase dramatically in private practice.

In comparison to the ABO OGS it is clear that despite low PAR scores some cases still did have a considerable need for treatment if the OGS was used as a gauge.

The co-examiners also felt that the final PAR score may be too subtle to detect the inadequacies of a finished case; this caused the PAR outcome score to be low because of its ordinal nature. This is contrary to the findings of Buchanan, Russell, and Clark [7] who showed that it is at least sensitive enough to discriminate between two treatment techniques using the percentage reduction value. It is not clear if the ABO OGS is more discriminating in its analysis of outcome because it contains more components than the PAR Index. It was found that removal of the Root Angulation Score lowered the overall ABO score and allowed substantially more of the sample to pass the examination.

Another study asked if success as defined by the ABO corresponds to satisfied parents and satisfied orthodontists. [45] Not only did the parent's opinion of treatment outcome not correlate with the final ABO score, but the orthodontist's opinions of treatment outcome also did not correlate to the final score. Overall the authors found that there is no correlation between the orthodontist's satisfaction or the parent's satisfaction with treatment outcome (as seen on the ABO OGS), treatment progress, and esthetics. Another finding was that two orthodontists within the same practice do not even agree on what is a good standard of care. They found that the ABO scoring system was a highly subjective measure. It would appear that satisfaction is affected by factors that are difficult to measure with reliability and validity. The authors suggest that following ABO treatment standards is not an indicator of success for orthodontists; the true predictors of success are not obvious. [45]

The ABO OGS has recently been used to evaluate treatment outcomes from two different bracket systems. [46] They found that 108 cases treated with one bracket system did show a mean score significantly better than those treated with a competing system, although both of the mean scores (31.31 and 37.69) were high enough to state that a large number of these cases would fail the ABO phase III examination. By comparison the results found from the Alberta study showed a mean deduction of 25.16 ABO OGS points. Thus, the average case treated in Alberta would still pass the ABO examination; another indication of the high standard of care in existence in this population.

In Chapter four an analysis of factors that may be related to outcome was carried out. O'Brien et al [47] investigated the relationship between PAR Score as an outcome variable and time, initial PAR scores, and extraction therapy. While the duration of treatment was found to be associated with Pre-treatment PAR as well as extraction therapy, the only variable that influenced the percentage change in PAR was the pre-treatment PAR score. The present study found that the Alberta population incurred a mean treatment time of 24.14 months. This was slightly higher than another similar study which used the PAR Index to report outcomes. [41]

It was found in another study [48] that longer treatments than the mean did not result in a clinically significant lower residual malocclusion. They also found that patient age had no effect on treatment outcome. Overall the authors found very little to explain the variance in finished cases including the absence of any effect due to orthodontic qualifications.

Although a relationship between operator experience and outcome was found in the present study, no such relationship was seen by Tulloch et al. [49] They also investigated treatment time and amount of crowding but found no connection through regression analysis to the outcome values. It is likely that factors unaccounted for by the study are at play in the eventual outcome such as overall treatment efficiency, patient motivation or cooperation. Birkeland et al [42] found that gender and extraction/nonextraction made no difference in long term results. This agrees with findings [50] which showed statistically identical Percentage PAR reduction as well as final PAR score for extraction and nonextraction groups, although the extraction group required a mean of 3.6 more months to bring to the end of treatment. No relationship was found between treatment duration and PAR score change in another study. [41] In fact the authors found no useful predictors at all for the treatment standard.

5.5 Quality Assurance, Risk/Benefit Considerations and Future Research

A "quality" outcome or a qualitative study is not easily subjected to measurement or statistical analysis. There is no consensus on cephalometric measures, reasonable treatment time, or amount of patient and parental happiness. We are responsible for meeting the patient's expectations and providing them with some reasonable measure of stability as well as the ethically requisite goal of doing the best for any given patient while doing the least harm.

Generally dentistry attempts quality control at three levels. The first level is dental education by an accredited dental school and by examination at a national level. The second is by specialty training, again taken from accredited schools. All specialty programs must meet the requirements of the American Dental Association's Commission on Accreditation of Dental and Auxiliary Educational Programs, which with the Council on Dental Education (of the American Association of Orthodontics), defines the area of specialty practice, prepares guidelines for the program, and accredits them. The third is the implied level of practice performance set as a standard within a community of similar professionals. Realistic standards of practice can be established only by analyzing the level of treatments in a wide variety of actual practice settings by a large number of practitioners. However if the public is to be protected there should be one standard of practice regardless of the qualifications or experience of the orthodontist. Rigorous scientific methods of defining practical standards of treatment for all routine orthodontic problems are required. Methods of treatment may vary as long as the outcome is similar for a similar patient. All graduate programs should be synchronized with respect to didactic and clinical requirements such that acceptable standards are met from the moment of graduation rather than establishing differing levels of care provision within the same specialty. It is a challenge to measure competencies in orthodontics due to the complex cognitive, analytical and psychomotor skills involved. [51] This is why it is necessary to build quality assurances and assessment as central tenets of dental and orthodontic specialty education. While standardized measurements of treatment outcomes are necessary in order for this process to be acceptable, Schleyer et al [51] recommend that the real significance of special qualifications such as the ABO certification be transparent and meaningful both to colleagues and patients.

Because orthodontic treatment outcome indices appear to be based on little more than informed opinion it is worthwhile to review several findings from the literature. It is difficult to say with conviction that fixing a malocclusion is preventive for periodontal disease. Geiger [52] reviewed the literature and found no data indicating periodontal health differences among Angle Class I or Class II patients. Nor was there a periodontal health difference between the normal side and the Class II side in subdivision cases. There was however a slight increase in periodontal disease in cases with severe overjet. He also found that neither crowding nor spacing were associated with periodontal destruction. No relationship between axial inclination of anterior teeth and periodontal status was found; in addition to proclined or upright incisor position compared to normal inclinations. Teeth in crossbite (anterior or posterior) had no increase in disease compared to teeth with normal bucco-lingual relationships. Posterior teeth with abnormal axial inclinations did show an increase in periodontal disease. It is difficult then to speculate whether periodontal findings are directly caused by, contributory to, or coincidental with local malocclusion factors. Unfortunately in studies examining the role of occlusion in the periodontal disease process limitations exist. The incidence of factors such as extreme overbite may be too small to show statistical significance or they may become masked or lost in the data. Several authors found that the presence of certain malocclusion traits may call for special oral hygiene efforts but do not justify orthodontic therapy. [53] In a related study no relationship was found between malocclusion traits and caries prevalence. [54] Shaw, Richmond and O'Brien state that only the most severe traits of malocclusion have a deleterious effect on dental health. [26] They specify that these significant components are large overjets greater than 6 mm, traumatic overbite, and impacted teeth. However Buckley states that vertical overbite, horizontal incisor overjet, and posterior cuspal interdigitation are unrelated to periodontal health. [55]

There is no evidence that achieving an optimal occlusion has any influence upon long-term dental stability, or masticatory function. [17] Jarvinen also comments that occlusal indices that reflect opinions about the disadvantages and health risks of malocclusion are conventional despite the fact that it is no longer clear that the risk of caries, periodontal disease, and TMD are indicators for orthodontic treatment. [56] While it is true that deep overbite may create risk of gingival and periodontal damage [57], overjet may increase risk of anterior incisor trauma, and a displaced bite can adversely affect mandibular growth, it is impossible to determine the weight or relative importance of such factors. [56] However Shaw [26] found little evidence to support the view that orthodontic treatment had a significant impact on reducing oral disease. Thomson found that there was no significant difference in caries experience, periodontal disease occurrence, or tooth loss between those who had and had not been treated by age 26 in his study group.[64]

Despite this obvious shortcoming the occlusal index is still commonly used. [56] The AAO does not recognize any index as a scientifically valid measurement of the need for orthodontic treatment. [24] It is felt that this statement is equally true today since no decisive new information about the consequences and disadvantages of malocclusions was found in the 1990's.[56] Instead, facial esthetics and psychosocial factors are becoming increasingly important in the discussion of consequences of malocclusion and benefits of treatment outside of occlusal trait improvement. [6 56 58]

Further research may include gathering as many consecutively treated cases from ABO diplomats who have recently (after 1997) achieved this status, and evaluating these consecutive cases. This would most likely give a more realistic idea of what "Board Certified" orthodontists are capable of on an unselected sample and would probably more closely approximate the standard which most orthodontists can not only hope for but achieve within a reasonable time frame given the numerous other factors that can complicate treatment. Another research suggestion would be to validate the PAR index with a new weighting system that is measured against such a large number of North American practicing orthodontists that its utility cannot be questioned.

It is difficult to say how much orthodontics improves the outlook of a patient, particularly when they are children or adolescents. One of the main reasons for this is that orthodontics is performed when a child is undergoing major life changes. If would be difficult to isolate the psychosocial effect from other physical and mental changes that the individual is experiencing. Research should investigate valid measures of perceived oral health quality of life in order to ascertain what it is that seekers of orthodontic treatment desire and if these needs are adequately met when analyzed again posttreatment. One of the main areas to examine is the perception of oral esthetics and its reliability as well as validity. This may in the future be used as a primary outcome measure.

Another direction for further research is to re-examine our position on what constitutes a desirable occlusion and consider either verifying or moving away from the biomedical model of health and disease as foundations for orthodontic treatment. It may come to the point that the consumer's desires and subjective preferences form an integral part of the overall treatment philosophy and goals of the orthodontist. This necessitates a certain amount of faith that individuals will be able to make reasonable judgments about the effect which a malocclusion may have on their lives and then either accept, modify, or change orthodontic recommendations for treatment.

Rinchuse and Rinchuse state that malocclusion is not associated with morbidity or mortality. [59] Class I molar has not been determined to be healthier than class II or Class III and Angle's Classification is not a reliable measure of health or disease. It is an erroneous belief that orthodontic treatment will promote a stable, healthy dentition that will survive longer than an untreated dentition. It does however improve the psychosocial dimensions of the patient and they feel that is what we are really treating. While it is relatively easy to measure marginal ridge heights and suggest that this provides a measure of clinical excellence a reliable and valid measure of the improvement in psychosocial wellbeing is what is necessary to measure treatment success. While Angle's Classification is the most widely used and accepted occlusal classification system it has several disadvantages [31]: It does not include all malocclusion types, it does not address vertical or transverse dimensions, and it lacks consideration for the face. They examined Angle's system and found that it was unreliable and imprecise. The authors state that this imprecision in turn can lead to diametrically opposed treatment plans even for the same patient. Keeling et al[60] found that excellent reliability only existed for evaluating the presence of a posterior crossbite despite the numerous dental and facial aspects of malocclusion that are recorded in a typical clinical orthodontic examination. They found only moderate reliability for judging facial convexity, overbite, overjet, and molar classification. Further study on clinical measures of malocclusion is required.

Bos, Hoogstraten and Prahl-Anderson found that there is a significant correlation between the patients' satisfaction with dentofacial appearance and expectations of orthodontic treatment [58]. It is apparent that while orthodontic specialists are primarily concerned with the correction of occlusal problems it is equally important to gain a complete understanding of how the patient views their own occlusion. Patients who are already satisfied with the appearance of their teeth might have entirely different expectations of the final occlusal result than those who begin treatment dissatisfied. This implies that success of treatment may be better measured by a tool that considers overall patient satisfaction than specific occlusal criteria.

It is important that we base treatment as a whole on the evidence. Without utilization of best evidence, clinical practice based on traditional wisdom is unlikely to be in the best interests of our patients [61]. The focus of outcome indices should be on published scientific evidence rather than erroneous historical assumptions. The health gain from orthodontic treatment should be considered in psychosocial terms rather than from the perspective of oral disease prevention/cure.

Improvement in facial appearance is an objective common to all orthodontists despite the lack of a precise definition of the "ideal" facial proportions [62]. Further study of reliable assessments of these values is recommended. There is also no general agreement on criteria to distinguish between orthodontically acceptable and non-acceptable occlusions after the completion of dental development.[15] The authors suggest that without functional considerations the judgment of orthodontic treatment outcome has little value. Further research is required to investigate characteristics of occlusion that include functional components showing validity and acceptable reproducibility.

It is obvious that severe malocclusions may result in impaired craniomandibular function and have an unfavourable influence on facial and dental attractiveness, which may in turn have psychosocial implications. [63] Thus a thorough evaluation of the quality of orthodontic treatment should involve improvement in other factors such as skeletal relationships, facial profile, psychosocial factors such as perception of self-worth, and lack of iatrogenic complications.

It has been concluded that malocclusion has little impact if any on diseases of the teeth or supporting structures [65] and that the lack of orthodontic therapy in adolescence does not appear to influence subsequent development or non-development of periodontal disease in adults.[66] Hunt's research examined the perceived benefits of orthodontic treatment by dental professionals. [67] Dentists and orthodontists rated psychosocial factors such as improved physical attractiveness, self-esteem, and self-confidence as important benefits of treatment. However they also still believe (despite available evidence) that orthodontic treatment will reduce susceptibility to dental disease such as caries and periodontal disease as well as decrease overall oral discomfort. When their sample was re-examined by age, younger orthodontists rated psychosocial benefits more highly indicating that older orthodontists were still expressing opinions based on the prevailing wisdoms at the time of their specialty training. The younger (or less experienced) orthodontists were trained at a time coinciding with the appearance of longitudinal studies in the literature that failed to endorse the health benefits of orthodontic treatment.

With respect to the opinion that teeth must be placed to avoid improper contact relationships, in a recent literature review Marklund and Wanman [70] examined the body of evidence regarding balancing/non-working side contacts. In fact the distinction between what are called contacts and what are called interferences is unclear to the authors as many studies did not make any clear definition. They found that malocclusions do not increase the probability of bruxism, and similarly occlusal interferences had no significant influence on bruxism. The authors proposed that at present there is no uniform body of scientific evidence supporting a balanced occlusion in favor of a mutually protected occlusion or vice versa. Longitudinal studies examining different types of occlusal contacts and their risk for developing signs and symptoms of temporomandibular disorders are lacking. This is a complicated item to study as there appears to be no current definition of the point at which the adaptability of the stomatognathic system to an occlusal interference becomes unable to cope with the contact. It is impossible to determine the stage of occlusal settling present when the posttreatment records were taken, but it seems reasonable to suspect that further physiologic settling might occur to negate the effect of any minor interference. In a 20-year follow-up study, analyzing the influence of orthodontic treatment on signs and symptoms of temporomandibular disorders it was found that no single occlusal factor is of major importance in the development of TMD. [71] The authors also found that there was no statistically significant difference in the prevalence of TMD signs and symptoms between subjects with or without history of orthodontic treatment.

Pahkala and Laine-Alava [72] studied early signs of different orofacial dysfunctions to see if malocclusions could predict the development of TMD in adolescence. They found that tendencies to open bite, both mesial and distal molar occlusion, and increased and decreased overjet were occlusal anomalies associated with TMD. Unfortunately it is difficult to quantify the amount of gross malocclusion traits which are implicated as local factors in the etiology of TMD, not to mention the residual or negligible amounts of occlusal factors remaining in a treated individual that might predispose that person to future temporomandibular problems. Central factors are likely also significant in any etiology of TMD. Further research of these and all functional aspects of occlusion must be added for studies on the outcome of orthodontic treatment. [16]

Cunningham and Hunt state that traditional outcome measures are of little interest to the patient and that some form of real-life outcome measure is required in the current mode of treatment delivery. [68] These values must be important to the patient as well as the treatment provider. An increased emphasis on Oral Health-Related Quality of Life (OHRQL) components such as cosmetic, elective, and psychosocial features is recommended.[69] Future research based on the domains of physical status, psychological status, social interactions, economic/vocational status, and spiritual status would seek to measure not just the improvement seen from a change in malocclusion components but the impact from that change in terms of the investigated domains. The oral cavity is not an autonomous anatomical landmark. New research focus should be on its condition and its effect on health, quality of life and well being of the individual. This is complicated by the fact that orthodontic treatment is undertaken at a time when most patients (children and adolescents) are undergoing major life changes and it would be difficult to filter out what is due solely to the treatment.

Psychosocial consequences of malocclusion may be more appropriately studied and scored as an outcome measure if research can find agreement on what constitutes an esthetic outcome in the future. According to Firestone et al [73], no index has been validated on its underlying health-based principles. No person with high treatment need which was unmet suffered more dental health or psychosocial problems than those with little or no residual need for treatment. Nurminen et al [14] found in their study that the major reason for patients seeking orthodontic-surgical treatment was “problems with biting and chewing” followed by “dissatisfaction with facial appearance”. This illustrates a problem with both the PAR Index and the ABO

OGS as neither considers patient happiness (in terms of function or esthetics) in the outcome of treatment.

One of the goals we use to assess outcome is the final Angle class of the result. Tang and Wei found that Angle's method of classifying malocclusion is probably the most widely used qualitative method of recording malocclusion [74 75]. However there is no universally accepted measure for measuring malocclusion. Critiques of Angle's method include [31]:

- It disregards facial esthetics.
- It does not factor in the three-dimensional aspect of malocclusion;
- It only takes into account anteroposterior deviations in the sagittal plane.
- It is not very reliable.
- It does not account for cases with subdivisions on the left or right sides.
- It is inaccurate where tooth movements have occurred due to crowding or premature loss of deciduous teeth, leaving clinical judgments open to subjective opinion on what the true underlying nature of malocclusion is.

It is recommended that further research be done to measure malocclusion in quantitative terms that are more universally accepted and less open to subjective interpretation. Perhaps another direction of research should be in other means of measuring a malocclusion. Hisano and Soma [76] suggest that another way of defining goals of orthodontic treatment be in terms of maximizing the efficiency of energy

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It is recommended that further research be done to measure malocclusion in quantitative terms that are more universally accepted and less open to subjective interpretation. Perhaps another direction of research should be in other means of measuring a malocclusion. Hisano and Soma [76] suggest that another way of defining goals of orthodontic treatment be in terms of maximizing the efficiency of energy utilization during mastication. They showed that the efficiency of an Angle Class I occlusion with rigid interdigitation is highest and decreases in malocclusions when masticatory movement must compensate to enhance the efficiency of food breakdown. They also suggest that other aspects of oral health such as occlusal trauma, periodontal disease, and TMJ apparatus be reexamined from the perspective of energy preservation, and that it should not be necessary to correct a malocclusion if masticatory efficiency is already high.

It has been realized that the success of treatment must be defined not just in terms of the objective findings of clinicians but also in the context of the patient's perceptions of what was achieved. Patient centered care is likely to become another new research focus for treatment outcome assessment. [77] It will not only consider the patient's wants, needs and preferences but also the psychological, social, cultural and economic factors that drive their decision to accept and evaluate their own treatment.

Orthodontic treatment is unique in that it is a treatment that is directed toward correction of variation from an arbitrary norm. Traditional wisdom has suggested that the aims of orthodontic treatment are to improve dental health and esthetics. As stated however a critical evaluation of these aims reveals that only the most severe traits of malocclusion are deleterious to dental health. Arguably, orthodontic treatment outcome should only be evaluated using quality of life measures. Development of these measures is an attainable aim. This approach is more valid than the traditional approach of evaluation based on provider derived indices that mean little to the patient. [78]

When submitting cases to the ABO the diplomat-candidates should remember that this form of peer review is not without its faults. Although the ABO states that their criterion is valid [3] it still appears to be imprecise between examiners and may not be free from bias. The agreement by the ABO on traditional notions of occlusal perfection might only be an indication that the examiners share the same set of subjective prejudices. It may not be in the public's best interest to say that all treatment provided by orthodontists is perfect but it would be equally unreasonable to establish multiple standards of care within the same specialty. It is doubtful that the perfect occlusion is achievable especially in the long term. There is a likelihood that in any finished case there are flaws present, recognized or not. The critical question is: Are the flaws important and do they really distinguish an orthodontist from his peers? We might be better off accepting a reasonable result given the limiting factors that patients present with rather than rejecting that result due to adherence to dogmatic standards. Orthodontics will continue to exhibit the qualities of a desirable specialty as long as we do not rigidly adhere to dogmatic ideals of specific outcomes but instead apply the art and science of skill, knowledge, and judgment in a reasonable manner.

Orthodontic consumers have very high outcome expectations [79]. Also, the parents of patients with severe malocclusions, overjet, or midline deviations have expectations that exceed probable treatment outcomes. Orthodontists should consider that consumers seeking their services have increased expectations not necessarily related to the treatment outcomes. The mere presence of deviations from an ideal occlusion should have no influence on orthodontic treatment decisions. [80] The research in this paper suggests that there may be valid utility in the PAR Index and ABO OGS for examining treatment outcomes from two perspectives. We must keep in mind that the results have limited interpretation but that they still illustrate the standard of care. It should be expected that their use will continue for the time-being until the profession can assign meaningful and reproducible ways of measuring patient satisfaction with respect to increased emphasis on esthetics.

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Chapter Six

Appendix

6.1: Conventions for the PAR index

General:

1. All scoring is cumulative
2. There is no maximal cut-off level
3. The occlusion should be scored disregarding functional displacement (this cannot be determined from dental casts alone).
4. The contact points between first, second, and third molars are not recorded. The contact points between molars are so variable; however, severe deviations will produce a cross-bite and will be noted in the buccal occlusions.
5. If the contact point displacement is as a result of poor restorative work (restorations or crowns), the displacement is not recorded.
6. Contact points between deciduous teeth are not recorded.
7. Extraction spaces are not recorded if the patient is to receive a prosthetic replacement; however, if space closure is intended, the distance between adjacent teeth should be noted.

Canines:

1. Where there are missing canines, displacements resulting from discrepancies between the mesial contact point to the first pre-molar and the distal of the lateral incisor should be recorded in the anterior segment.
2. Canine cross-bites should be recorded in the overjet section.
3. Contact points between the canines and pre-molars are scored as follows: the distal contact point of the canine to the midpoint on the mesial surface of the

adjacent pre-molar. (These contact points are so variable. When untreated normal occlusions were assessed this relationship seemed to be the most acceptable.)

Impactions:

If a tooth is unerupted and displaced from the line of the arch either buccally or palatally due to insufficient space, this is regarded as an impaction. However, if the tooth is erupted and displaced, the displacement score is recorded.

Incisors:

1. If there is agenesis of the upper incisor tooth or the tooth has been lost due to trauma or caries the procedure is as follows: (a) if the space is maintained (for a prosthesis), the distance between adjacent teeth is not recorded; (b) if the space is to be closed, the distance between adjacent teeth is recorded.
2. When recording an overjet, if the tooth falls on the line the lower grade is recorded.
3. If a lower incisor has been extracted or is missing, the centerline is not recorded.

Molars

1. Contact points between first and second molars are not recorded.
2. If the first molars have been extracted, the contact point of the second molar is recorded.

6.2: PAR Convention Tables

Table 1 Components of the PAR Index

1. Upper right segment
2. Upper anterior segment
3. Upper left segment
4. Lower right segment
5. Lower anterior segment
6. Lower left segment
7. Right buccal occlusion
8. Overjet
9. Overbite
10. Centerline
11. Left buccal occlusion

Table 2: Displacement Scores

Score	Discrepancy
0	0 mm to 1 mm
1	1.1 to 2 mm
2	2.1 to 4 mm
3	4.1 to 8 mm
4	Greater than 8 mm
5	Impacted teeth

Table 3 Mixed dentition crowding assessment using average mesio-distal widths

Upper		
Canine	8 mm	
1st premolar	7 mm	Total = 22 mm (impaction < = 18 mm)
2nd premolar	7 mm	
Lower		
Canine	7 mm	
1st premolar	7 mm	Total = 21 mm (impaction < = 17 mm)
2nd premolar	7 mm	

Table 4 Buccal occlusion assessments. (Temporary developmental stages and submerging deciduous teeth are excluded.)

Score		Discrepancy
Antero-posterior		
	0	Good interdigitation Class I, II and III
	1	Less than half unit discrepancy
	2	Half a unit discrepancy (cusp to cusp)
Vertical		
	0	No discrepancy in intercuspation
	1	Lateral open bite in at least two teeth greater
than 2 mm		
	Transverse	
	0	No cross-bite
	1	Cross-bite tendency
	2	Single tooth in cross-bite
	3	More than one tooth in cross-bite
	4	More than one tooth in scissor bite

Table 5 Overjet measurements

Score	Discrepancy
Overjet	
0	0-3 mm
1	3.1-5 mm
2	5.1-7 mm
3	7.1-9 mm
4	greater than 9 mm
Anterior cross-bites	
0	No discrepancy
1	One or more teeth edge to edge
2	One single tooth in cross-bite
3	Two teeth in cross-bite
4	More than two teeth in cross-bite

Table 6 Overbite measurements. Cross-bites including the canines are recorded in the anterior segment

Score	Discrepancy
Open bite	
0	No open bite
1	Open bite less than and equal to 1 mm
2	Open bite 1.1-2 mm
3	Open bite 2.1-3 mm
4	Open bite greater than or equal to 4 mm
Overbite	
0	Less than or equal to one third coverage of the lower incisor
1	Greater than one-third, but less than two-thirds coverage of the lower incisor
2	Greater than two-thirds coverage of the lower incisor
3	Greater than or equal to full tooth coverage

Table 7 Centreline assessments

Score	Discrepancy
0	Coincident and up to one-quarter lower incisor width
1	One-quarter to one-half lower incisor width
2	Greater than one-half lower incisor width

6.3: PAR Scoring Table and Component UK Weighting Factors

CASE NUMBER		

PAR COMPONENTS	RIGHT		LEFT								UN-WEIGHTED TOTAL	WEIGHTED TOTAL
Upper anterior segments	3-2		2-1		1-1		1-2		2-3			X1
Lower anterior segments	3-2		2-1		1-1		1-2		2-3			X1
Buccal occlusion	Antero-posterior				Right			Left				X1
	Transverse				Right			Left				X1
	Vertical				Right			Left				X1
Overjet	Positive					Negative						X6
Overbite	Overbite					Openbite						X2
Centre line												X4
									TOTAL			

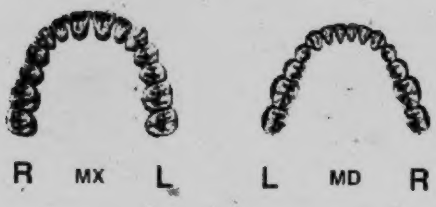
6.4: THE ABO Objective Grading System Scoring Sheet

CAST EVALUATION

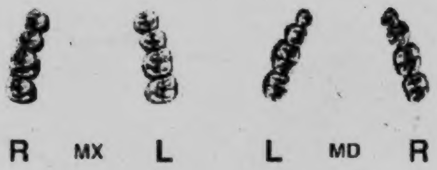
Case #: ____________

Total Score: ____________

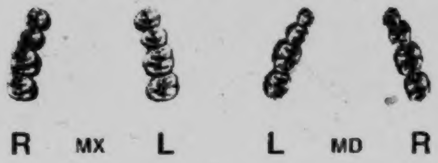
Alignment/Rotations



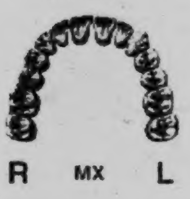
Marginal Ridges



Buccolingual Inclination

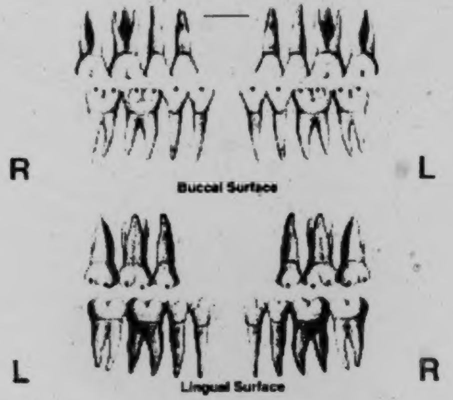


Overjet

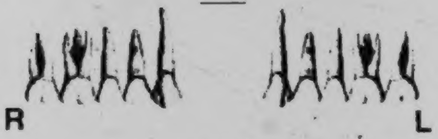


Note: Please mark extracted teeth with "X"

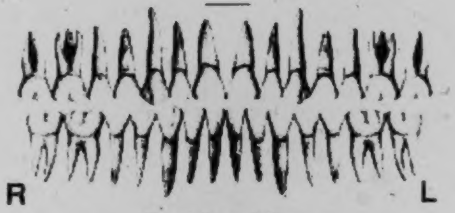
Occlusal Contacts


R
L
Buccal Surface
L
R
Lingual Surface

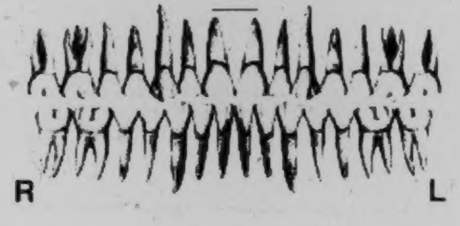
Occlusal Relationships



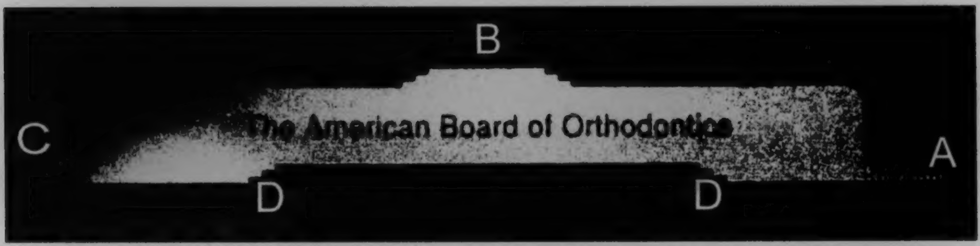
Interproximal Contacts



Root Angulation



6.5: The American Board of Orthodontics Measurement Instrument



A: This portion of the gauge is 1 mm in width and is used to measure discrepancies in alignment, overjet, occlusal contact, interproximal contact, and occlusal relationships.

B: This portion of the gauge has steps measuring 1 mm in height and is used to determine discrepancies in mandibular posterior buccolingual inclination.

C: This portion of the gauge has steps measuring 1 mm in height and is used to determine discrepancies in marginal ridges.

D: This portion of the gauge has steps measuring 1 mm in height and is used to determine discrepancies in maxillary posterior buccolingual inclination.

6.6: The American Board of Orthodontics Dental Cast Grading System Summary

ALIGNMENT

.5 - 1 mm = -1 for each tooth
> 1 mm = -2 for each tooth

MARGINAL RIDGES*

.5 - 1 mm = -1 for each posterior tooth interproximal contact
> 1 mm = -2 for each posterior tooth interproximal contact

* Do not include the canine premolar contact.
Do not include the distal of lower 1st premolar.

BUCCOLINGUAL INCLINATION**

0 - 1 mm = satisfactory
1 - 2 mm = -1 for each posterior tooth
> 2 mm = -2 for each posterior tooth
> 3 mm = -2

** Do not score the mandibular 1st premolars.

Upper 2nd molars can deviate up to 2 mm with no points deducted in transverse discrepancy cases. Then: 2 - 3 mm = -1

OCCLUSAL CONTACTS***

Contact = 0
0 - 1 mm = -1 for each posterior tooth cusp
> 1 mm = -2 for each posterior tooth cusp

*** Do not score the distolingual cusps of the maxillary 1st and 2nd molars if they are small. Do not score the lingual cusp of maxillary 1st premolars.

OCCLUSAL RELATIONSHIPS

0 - 1 mm = satisfactory

1 - 2 mm = -1 for each maxillary tooth from the canines to the 2nd molars inclusive

> 2 mm = -2 for each maxillary tooth from the canines to the 2nd molars inclusive

OVERJET

0 - 1 mm = -1 for each maxillary tooth
> 1 mm = -2 for each maxillary tooth

INTERPROXIMAL CONTACTS

.5 - 1 mm = -1 for each interproximal contact
> 1 mm = -2 for each interproximal contact

NOTE: Gauge width = .5 mm
Gauge height = 1 mm

ROOT ANGULATION

Parallel = 0
Not Parallel = -1 for each tooth
Root contacting adjacent root = -2 for each tooth

NOTE: Third molars are scored if they have erupted. If they are partially erupted or scheduled for extraction, they are not scored.